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Discover the ice giants at their brightest

The frozen secrets of Uranus and Neptune

#173 OCTOBER 2019

Sky at Night

THE UK'S BEST SELLING ASTRONOMY MAGAZINE

TOUR THE MILKY WAY

Take in 21 of our Galaxy's richest sights tonight

WINNERS REVEALED!

Insight Investment
Astronomy Photographer of the Year

EUROPE'S DARKEST SKIES

Why astronomers are heading east

MAKE A STAR TRAIL
Create your finest time-lapse video

MOONLIGHT SHADOW
Discover a necklace on a lunar crater

THE GREAT ESCAPE
A fast star's getaway from a black hole

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MiniTrack LX3: Fully mechanical photography mount for cameras up to 3kg (105.8oz) (6.6 lbs)

Sastong Night - Sassolungo da Col Raiser (Italy) – Photo: Cristian Fattinnanzi

NEW

Wide-field imaging, as depicted above, is possible with ease. The fully mechanical Omegon MiniTrack LX3 mount works just like a clock. No power necessary. No charging. No battery. Simply mount your camera onto the LX3 and wind it up. Easily capture wide-field images of the cosmos on your camera.

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The mount works like a clock, with 60-minute tracking - all without power and batteries. You can also adjust the tracking speed according to your needs.

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Welcome

Join us on a tour of our Galaxy's 21 top sights

The 2019 Insight Investment Astronomy Photographer of the Year winners have been announced and once again it is a vintage year, with stunning images capturing the beauty of the night sky in all categories, and groundbreaking photographs that push the boundaries of what can be achieved. See the winners in our gallery, starting on page 28.

If you're inspired by the photos taken by other amateur astronomers, we explore some unique locations for imaging in Jamie Carter's feature on eastern Europe's darkest skies on page 67. You'll also find expert guides to capturing and processing your astrophotos on page 76.

This month, one of the most alluring targets in the night sky for imagers and visual observers alike – our home Galaxy the Milky Way – arches overhead from horizon to horizon. Starting on page 36, Paul Money makes his way along this heavenly span, focusing on 21 top sights to view in the rich band of stars.

Glowing Milky Way-like in dark skies is another astronomical phenomenon which some will be less familiar with – the Zodiacal Light. This ethereal glow is sunlight scattered off countless motes of comet and asteroid dust floating in the Solar System's plane. Will Gater is your guide to identifying and photographing this alluring sight on page 60.

Tracing its way along a path within the Zodiacal Light is Uranus, which this month reaches its opposition point and is best placed for viewing. This distant world is a small sight perhaps, but our view belies its active nature. Jane Green brings us up to speed on the current understanding of it and its ice giant relation, Neptune, on page 72.

Enjoy the issue!

Chris Bramley, Editor

PS Our next issue goes on sale Thursday 17 October.

HOW TO CONTACT US

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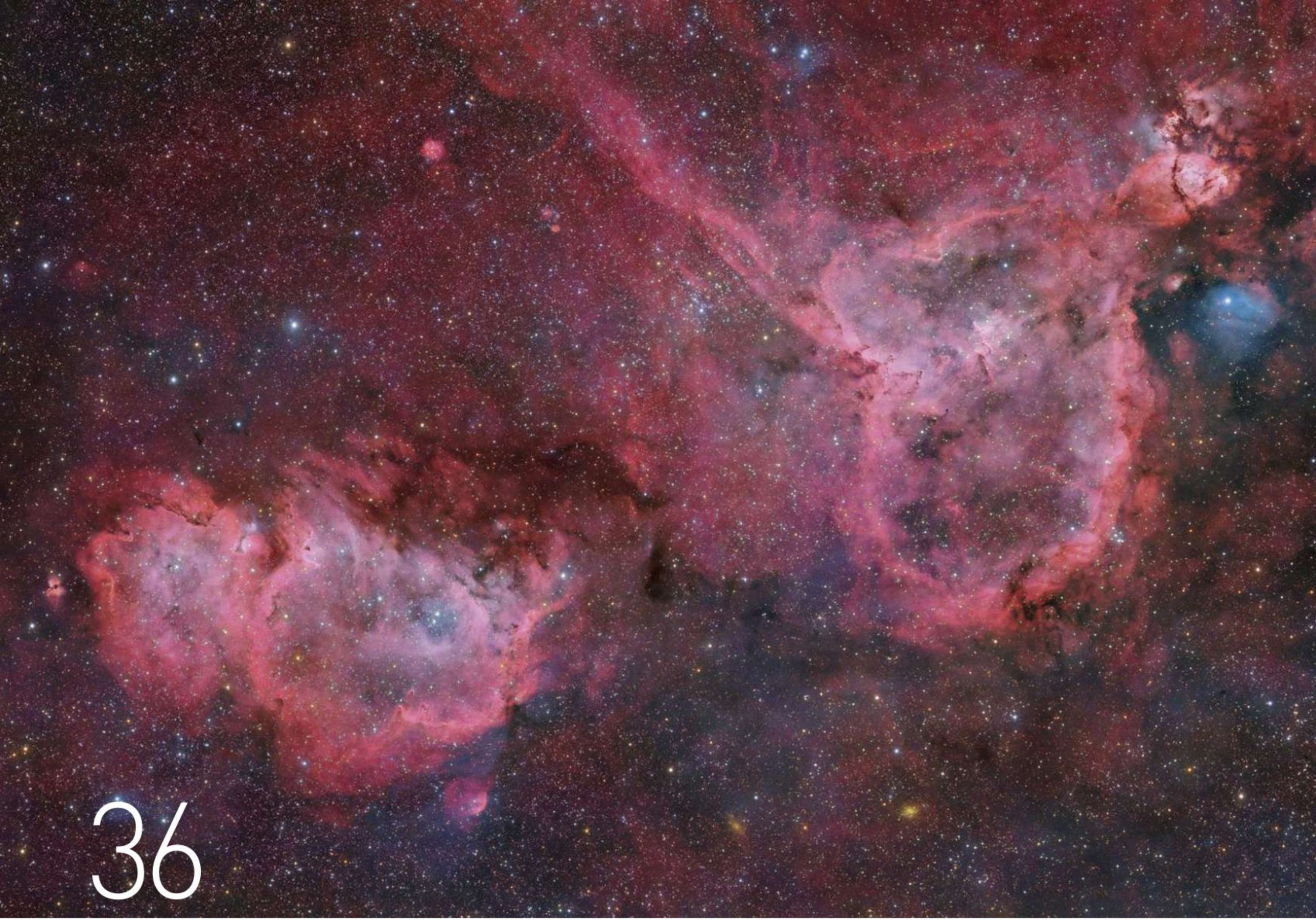

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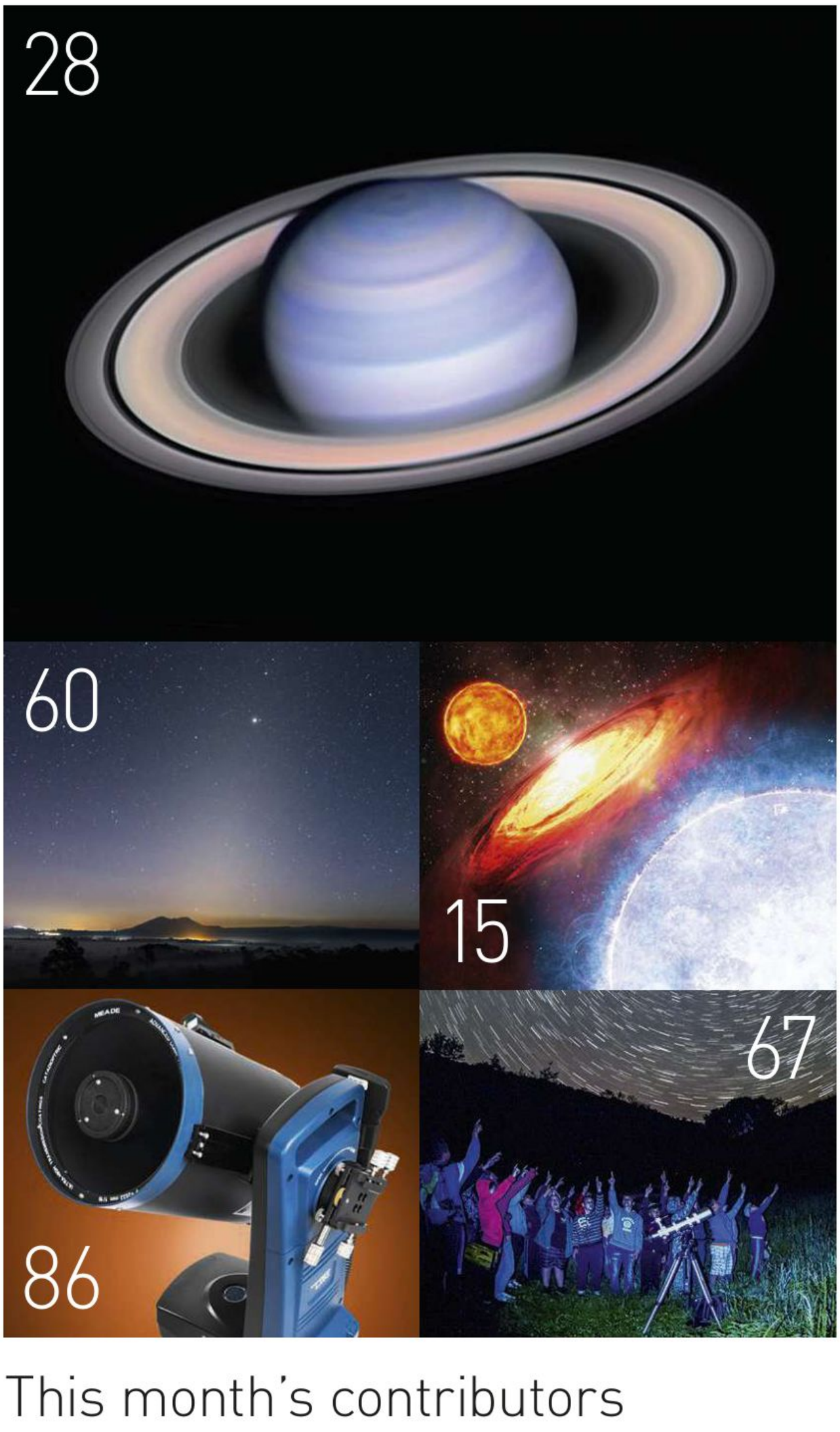
16-PAGE CENTRE PULLOUT

The Sky Guide

New to astronomy?

To get started, check out our guides and glossary at
www.skyatnightmagazine.com/astronomy-for-beginners



This month's contributors

Jamie Carter

Astronomer and author

Jamie discovers why stargazers are heading to eastern Europe to enjoy dark skies. See page 67

Tiffany Francis

Nature writer and stargazer

Tiffany reveals how nightwalking can combine a passion for astronomy and wildlife. See page 25

Will Gater

Astrophotographer

Will goes on the trail of the Zodiacal Light and its rarely seen companion – the Gegenschein. See page 60

Jane Green

Astronomy writer and presenter

Jane sheds light on our Solar System's two outermost planets. See page 72

Extra content ONLINE

Visit **www.skyatnightmagazine.com/bonus-content/3AHG5P9** to access this month's selection of Bonus Content.

October highlights

A Space Mission Special

The Sky at Night team visit ESA to find out how the agency selects space missions, and follow the story as the UK Comet Interceptor mission gets the go-ahead.

Interview: the mission to detect dark matter

Dr Jaret Heise reveals how the Sanford Underground Research Facility is hoping to solve one of the biggest mysteries in the Universe.

10 Things You Should Know About Space

Download and listen to chapters of a new audio book about the existence of extraterrestrials and why the night sky is dark.

Astrophoto gallery, extra EQMOD files, binocular tour, observing forms, deep-sky tour chart, desktop wallpapers...**and much more**

PLUS: Every month

Night-sky highlights

Pete Lawrence and Paul Abel discuss the top sights to see this month.

EYE ON THE SKY

A new view of the GAS GIANT

The tempestuous atmosphere of the iconic planet is brought to life in a brand new Hubble Space Telescope image

HUBBLE SPACE TELESCOPE, 27 JUNE 2019

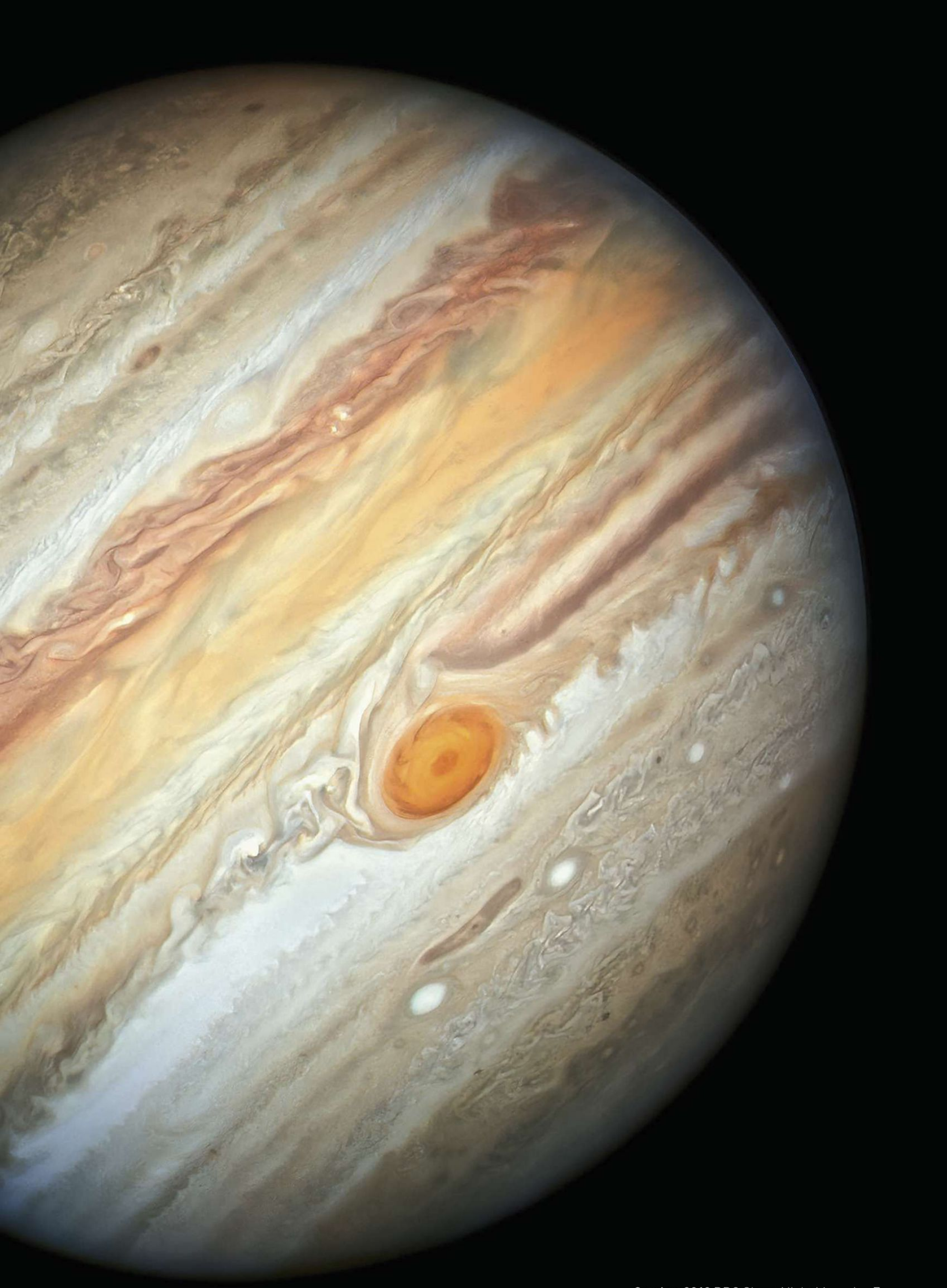
While NASA's Juno spacecraft continues to capture previously unseen views of Jupiter from its polar orbit, this Hubble portrait of the gas giant shows a more familiar perspective, yet with amazing clarity.

Up-to-date images of Jupiter like this one are revealing something intriguing about the gas giant: its Great Red Spot is shrinking. This huge anticyclonic storm spans a distance 1.3 times Earth's diameter and has been observed by astronomers for centuries. It is currently not clear what's causing the spot to decrease in size, but studies using both Hubble and Juno provide vital clues that may help planetary scientists find an answer.

What's also striking about this image is the detail in the numerous bands that create Jupiter's stripy appearance. These are generated by air in the planet's stormy atmosphere flowing in opposite directions at different latitudes, dictated by the thickness and height of ammonia ice clouds. The bands are kept separate by fast winds that can reach speeds of up to 650 kilometres per hour.

This image was captured when Jupiter was 644 million kilometres from Earth.

NASA/ESA/A SIMON (GODDARD SPACE FLIGHT CENTER) AND MH WONG (UNIVERSITY OF CALIFORNIA, BERKELEY)



◁ Seagull among the stars

VLT SURVEY TELESCOPE, 7 AUGUST 2019

Seagulls are well-known for their huge wingspans, but what about one stretching 100 lightyears across? That's the width of the Seagull Nebula, so-called due to its resemblance to a bird in flight. The nebula's seagull-like shape is actually made up from three separate clouds of dust and gas that are illuminated by the radiation from young stars born within.

▽ Galaxy's edge

SPITZER SPACE TELESCOPE, 31 JULY 2019

You could be forgiven for thinking that we see all galaxies as beautiful spiral structures, but in reality the Universe is not so accommodating. This thin red strip is a galaxy, NGC 5866, 44 million lightyears away that appears side-on from Earth, hiding its intricate form. The red colour is starlight absorbed by cosmic dust, then re-emitted and detected by Spitzer in infrared.

◁ A hot-headed history

MARS EXPRESS ORBITER, 8 AUGUST 2019

Mars is host to some of the largest volcanoes found in the Solar System, which planetary scientists believe may once have been very much active. This view of Mars's Terra Cimmeria reveals dark surface minerals like basalt, formed from volcanic ash and dust released during the Red Planet's ancient past.

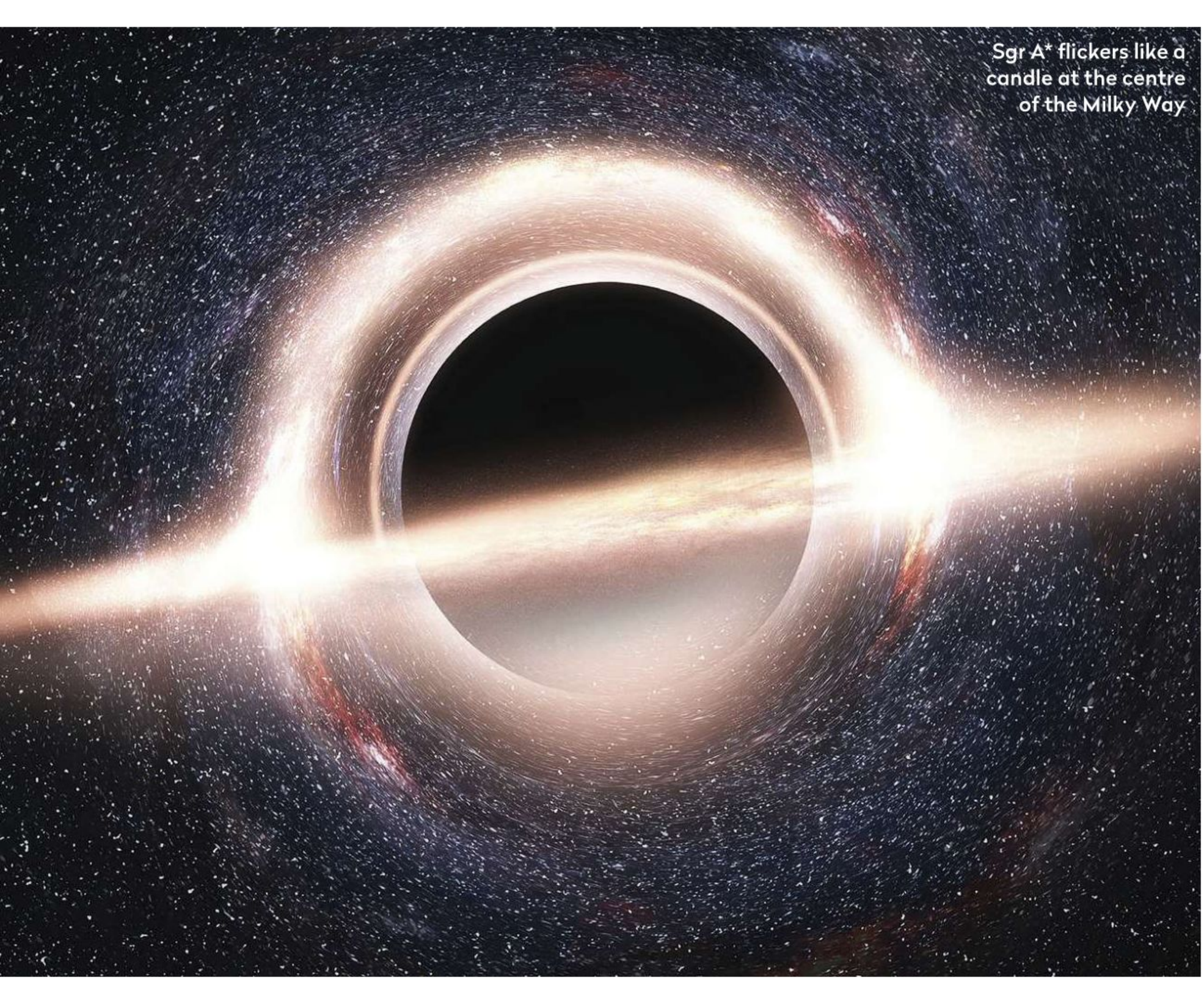
◁ The fate of our Sun?

HUBBLE SPACE TELESCOPE, 12 AUGUST 2019

Our own Sun may one day end up resembling this object, NGC 2022, known as a planetary nebula. When stars as massive as the Sun die, they swell up to become red giants and begin shedding their outer layers into space, forming an expanding shell of gas.

More **ONLINE**
A gallery of these and more stunning space images

ESO/VPHAS+ TEAM/NJ WRIGHT (KEELE UNIVERSITY), ESA/DLR/FU BERLIN, NASA/JPL-CALTECH, ESA/HUBBLE & NASA/R WADE



Sgr A* flickers like a candle at the centre of the Milky Way

KEANU2/ISTOCK/GETTY IMAGES, DREAMFRAMER/ISTOCK/GETTY IMAGES, NASA/JPL-CALTECH/MSSS/JHU-APL, K. SUDA & Y. AKIMOTO/MABUCHI DESIGN OFFICE/COURTESY OF ASTROBIOLOGY CENTER/JAPAN

Surprise flare at the heart of our Galaxy

Supermassive black hole suddenly becomes 75 times brighter

The supermassive black hole at the heart of our Galaxy, Sagittarius A* (Sgr A*), has been seen to flare 75 times brighter than normal.

An international team led by Tuan Do of the University of California, Los Angeles, turned the Keck Telescope in Hawaii onto the black hole in May. Sgr A* is up to five million times more massive than the Sun. The astronomers wanted to measure the positions of stars orbiting it, in particular one called S0-2 which closely approached it last year.

By their nature, black holes themselves are invisible. They show up due to light emitted from gas falling onto them. The team's first frame, shot in near-infrared light, showed Sgr A* to be 75 times brighter than expected. It then gradually faded over two hours.

Dr Do told us: "The brightness of Sgr A* varies all the time – it basically flickers like a candle. The first frame was actually the brightest we saw that night, which means it was probably even brighter before we started observing.

"It was so bright that I first mistook it for S0-2. Over the next few frames though it was clear that it had to be the black hole. It was really exciting to see. We are observing changes in activity that we haven't seen in 20 years of studying the region."

It is unclear what caused the brightening. Dr Do suggests that star S0-2 may have altered the flow of gas onto the black hole, or a delayed reaction to a passing stream of dust and gas in 2014.

https://arxiv.org/abs/1908.01777

Comment

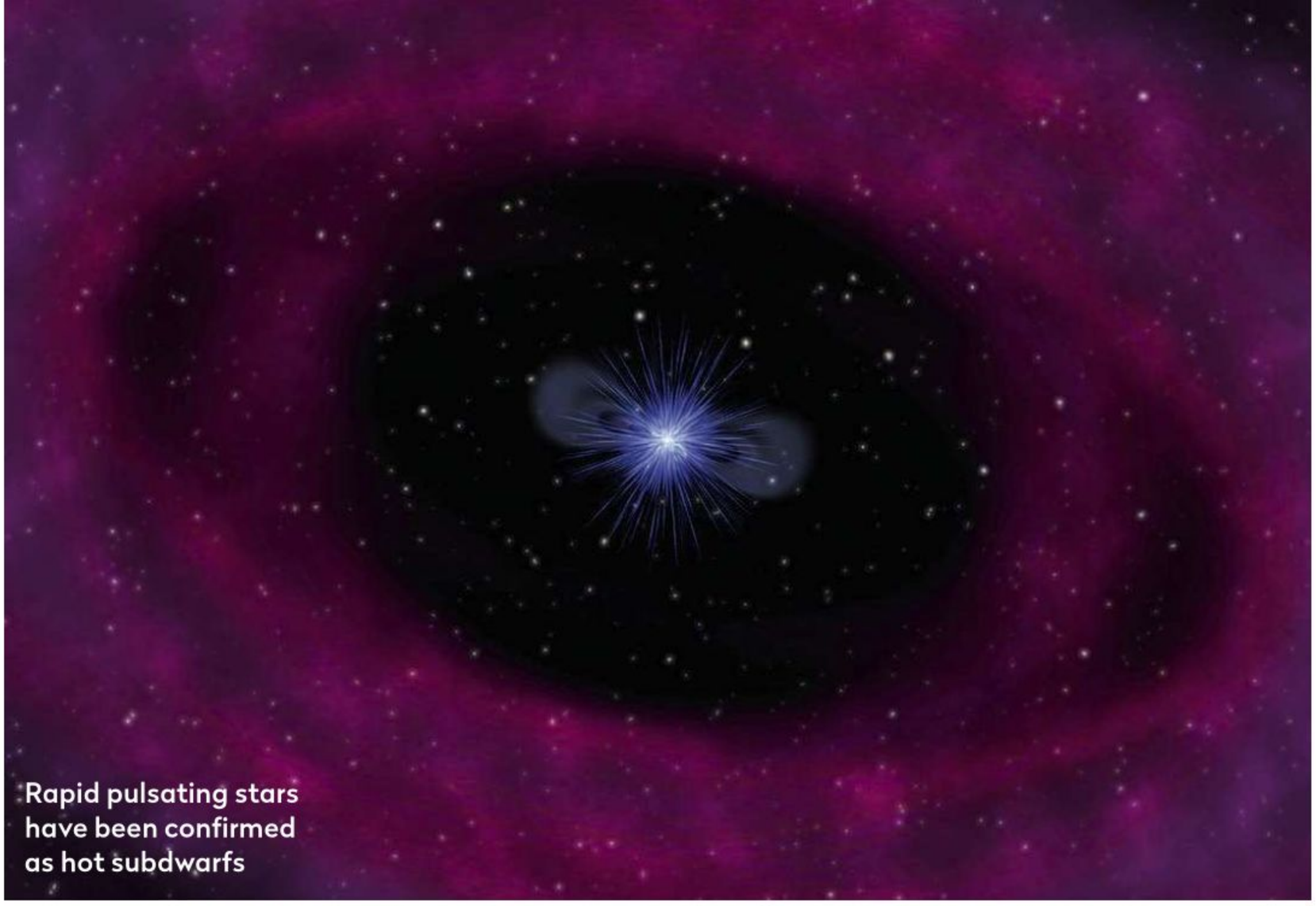
by Chris Lintott

These exciting observation results confirm that our Milky Way's black hole lives an interesting and variabe life.

The giant 'Fermi bubbles' of shocked gas that extend tens of thousands of lightyears away from the Galaxy's disc suggest that Sgr A* may have been more active in the past. When the Event Horizon Telescope team released their image of the black hole in M87 in April many had expected a similar image of Sgr A* – but its inherent variability between epochs of observation has made that difficult.

My own Galaxy Zoo project has shown that black holes switch their activity on and off; studying our own, local example will help us understand these results.

Chris Lintott co-presents *The Sky at Night*



Rapid pulsating stars have been confirmed as hot subdwarfs

New type of pulsating star discovered

Subdwarfs vary in brightness over just a few minutes

Astronomers have discovered a new, rapidly pulsating variable star. They were searching for binary stars with periods of less than an hour as part of the Zwicky Transient Facility sky survey. Four stars stood out, with regular brightness changes of up to 15 per cent within three to eight minutes. Further checks revealed they were single stars.

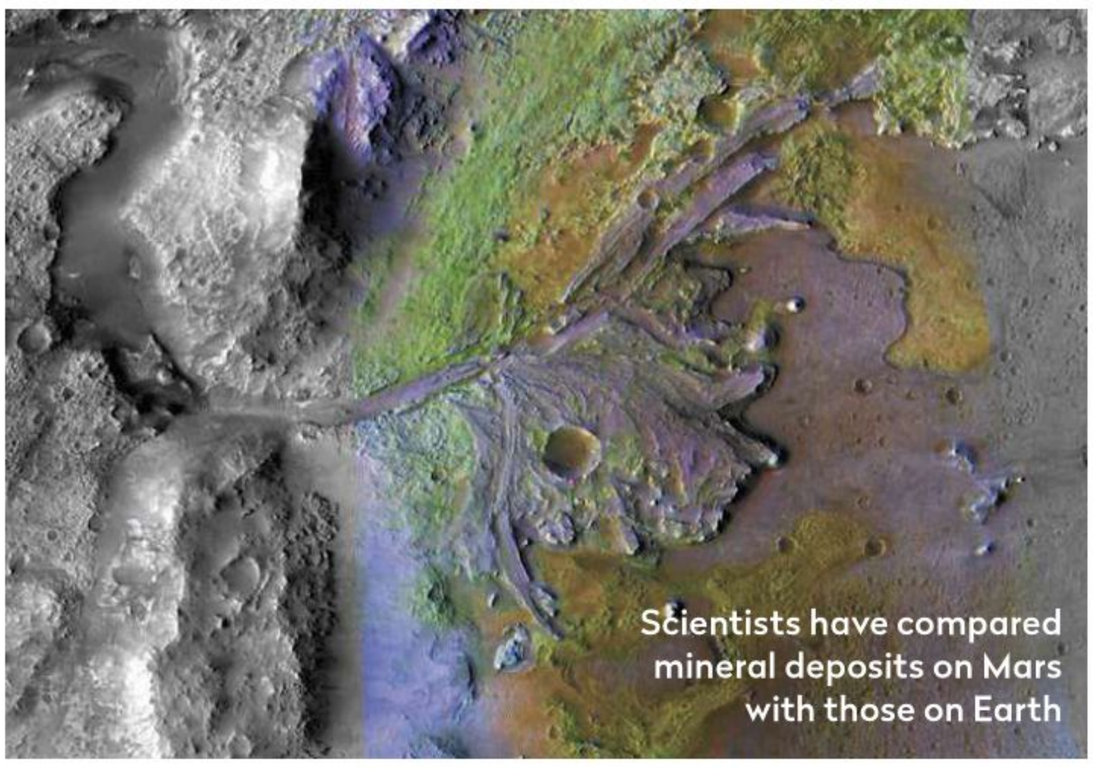
Dr Thomas Kupfer of the University of California Santa Barbara and colleagues at Caltech have identified the rapid pulsators as very hot subdwarfs, around a tenth the diameter of the Sun and less than half as massive.

The team believe the stars – which range from +16.5 to +19 in apparent magnitude – started life like the Sun but had their outer material stripped away by other stars before they could fuse helium.

Dr Kupfer says: "By studying pulsations in detail, scientists can learn about these stars' interior properties."

www.ztf.caltech.edu

Did rain storms kickstart life on Mars?



Scientists have compared mineral deposits on Mars with those on Earth

Mars had a warm enough climate 3–4 billion years ago for substantial rain storms and flowing water, providing conditions for life to develop, new research suggests.

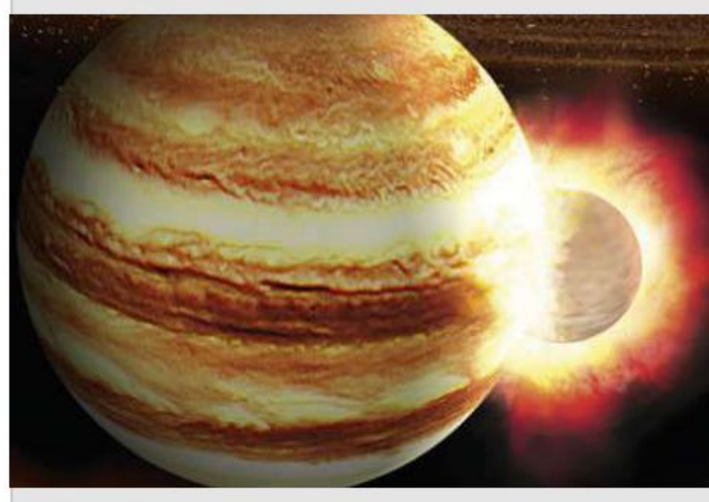
Scientists already knew ancient Mars had abundant water. Now Professor Briony Horgan of Purdue University, Indiana, has compared mineral deposits on Mars to similar on Earth. They indicate that the Red Planet enjoyed long periods of rainy weather, after which the water froze.

She said: "We know that the building blocks of life on Earth developed very soon after the planet's formation, and that flowing water is essential for life's development. So evidence of early, flowing water on Mars will increase the chances that simple life may have developed at around the same time."

In separate research, scientists at the Australian National University, Canberra, say they are closer to discovering the source of methane on Mars. Data from ESA's ExoMars Trace Gas Orbiter and NASA's Curiosity Rover suggests that emissions from the crater Gale vary over the course of each Martian day. Some believe the methane is from microbial life.

www.purdue.edu

NEWS IN BRIEF



Jupiter once hit by planet

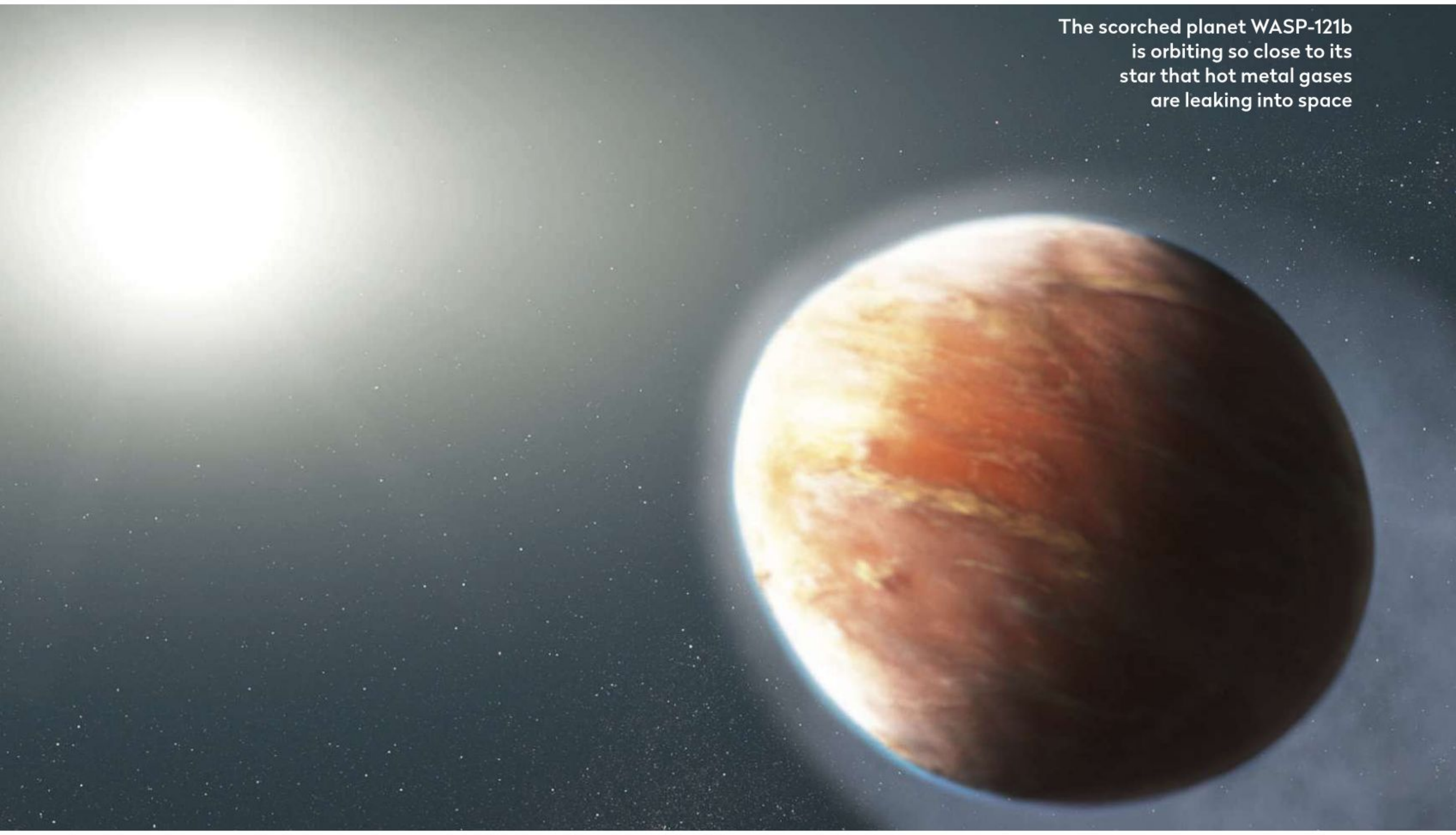
Jupiter was struck by a planet 4.5 billion years ago, suggest results from NASA's Juno probe. An impact that stirred up the interior would explain why Jupiter's core appears less dense and extends further than expected, say scientists from Rice University, Houston, and China's Sun Yat-sen University.

...and amateur detects a new smaller impact

A bright flash from a possible asteroid impact on Jupiter's South Equatorial Belt was recorded on 6 August by Ethan Chappel of Texas, using a CCD camera on his Celestron 8 telescope. The flash was the seventh strike recorded on Jupiter by amateur astronomers since Comet Shoemaker-Levy collided in July 1994.

How old is dark matter?

Elusive dark matter, which could make up 80 per cent of the Universe, may have existed before the Big Bang, says a new study at Johns Hopkins University. Professor Tommi Tenkanen argues that if it were a substance formed in the Big Bang, researchers would have detected a signal of it in particle physics experiments, but they have not.



The scorched planet WASP-121b is orbiting so close to its star that hot metal gases are leaking into space

NASA/ESA AND J. OLMSTED (STSCI), S. MUNRO, CARL KNOX/OZGRAV ARC CENTRE OF EXCELLENCE, DOTTEDHIPPO/ISTOCK/GETTY IMAGES

Gas giant puts on a heavy metal show

Hubble spots magnesium and iron gases escaping from scorching hot world

Observations with the Hubble Space Telescope have revealed an exoplanet so hot that heavy metals are boiling away from its atmosphere and escaping into space.

The alien world, dubbed WASP-121b, is a gas giant of the type termed a 'hot Jupiter'. Its host star, which lies around 900 lightyears away, in the constellation of Puppis, is brighter and hotter than the Sun.

WASP-121b orbits perilously close to the star which bombards it with ultraviolet light, sending the temperature of its upper atmosphere soaring to a scorching 2,500°C. That is around 10 times hotter than observed in any other exoplanet's atmosphere, according to a team led by Professor David Sing of Johns Hopkins University in Baltimore, Maryland.

The powerful gravitational pull of the nearby star has also distorted the shape of WASP-121b so that the planet is lucky not to have been ripped apart, and it resembles a rugby football.

Hot Jupiters are usually still cool enough inside for their heavier elements to condense into clouds. But the extreme heat at WASP-121b is stripping away its atmosphere, allowing magnesium and iron gas to stream into space, observations with Hubble's Imaging Spectrograph show. Astronomers define 'heavy metals' as any elements heavier than hydrogen and helium.

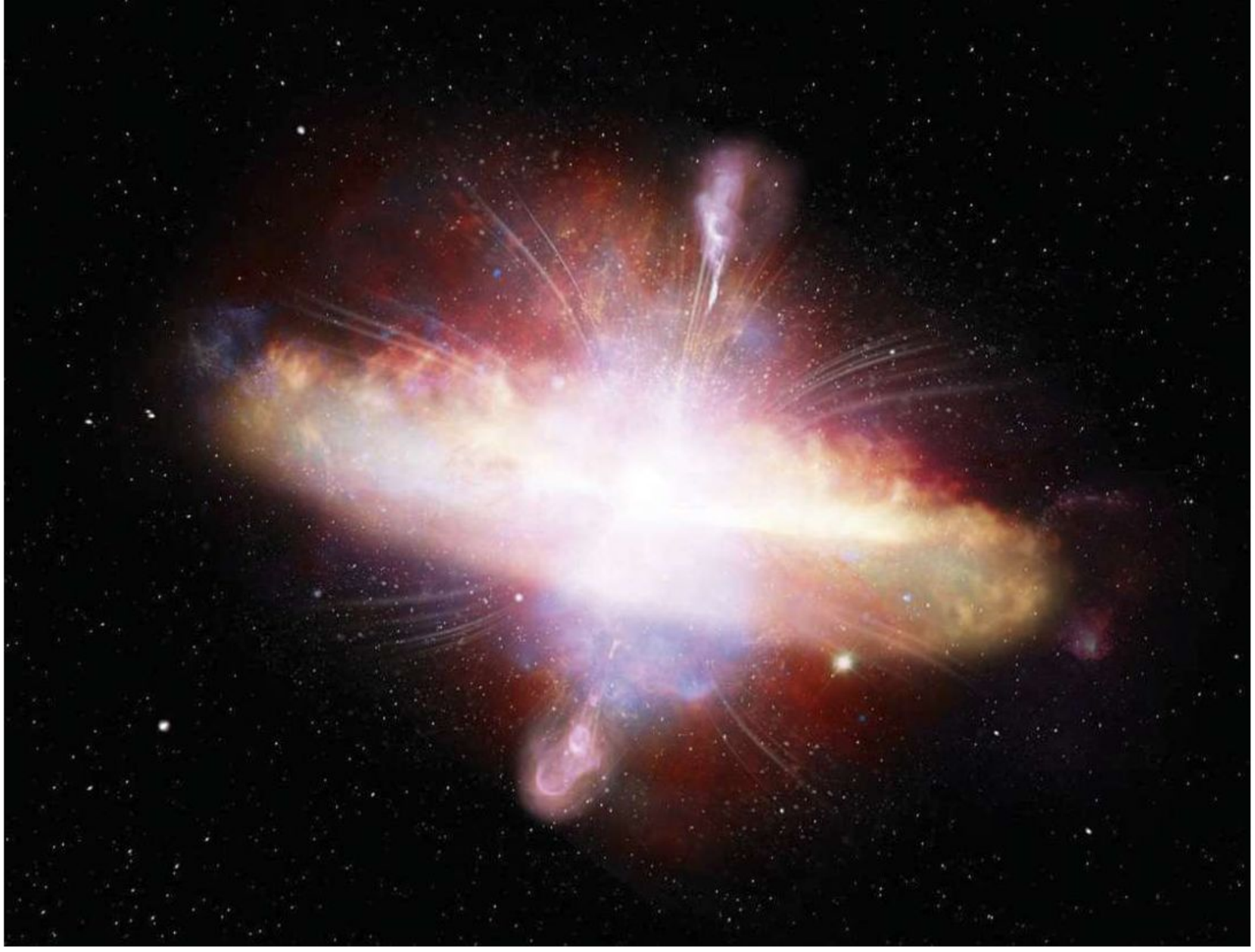
Professor Sing explains: "Heavy metals have been seen in other hot Jupiters before, but only in the lower atmosphere, so you don't know if they are escaping or not. With WASP-121b, we see magnesium and iron gas so far away from the planet that they're not gravitationally bound."

He says the escaping gases might themselves be contributing to the high temperatures by making the atmosphere more opaque in ultraviolet light.

"We picked this planet because it is so extreme," says Sing. "We thought we had a chance of seeing heavier elements escaping. It was a surprise, though, to see it so clearly in the data and at such great altitudes so far away from the planet. This planet is being stripped of its atmosphere."

WASP-121b was discovered in 2015 in observations made by a robotic bank of eight cameras set up at the South African Astronomical Observatory, Sutherland, as part of the UK-led Wide Angle Search for Planets (SuperWASP).

www.jhu.edu



▲ True colours: astronomers have studied the colour properties of 10,000 quasars

Quasars are red, violent then blue

Colour reveals brief burst of energy into surrounding gas and dust

UK astronomers believe they have solved the riddle of why some quasars are red rather than blue.

Quasars are the most energetic objects in the Universe, shining thousands of times brighter than galaxies like our Milky Way, and powered by supermassive black holes.

The majority are blue, but a number are red. The conventional view has been that red quasars are really blue too, but appear red because they are angled away from our line of sight.

However, a team at Durham University which has studied 10,000 quasars say they are indeed red, and are being observed during a brief and violent early phase when their black hole ejects enormous energy into surrounding clouds of dust and gas.

This energy blows away the dust and gas to reveal a blue quasar. Observations of increased radio emission in red quasars support this theory.

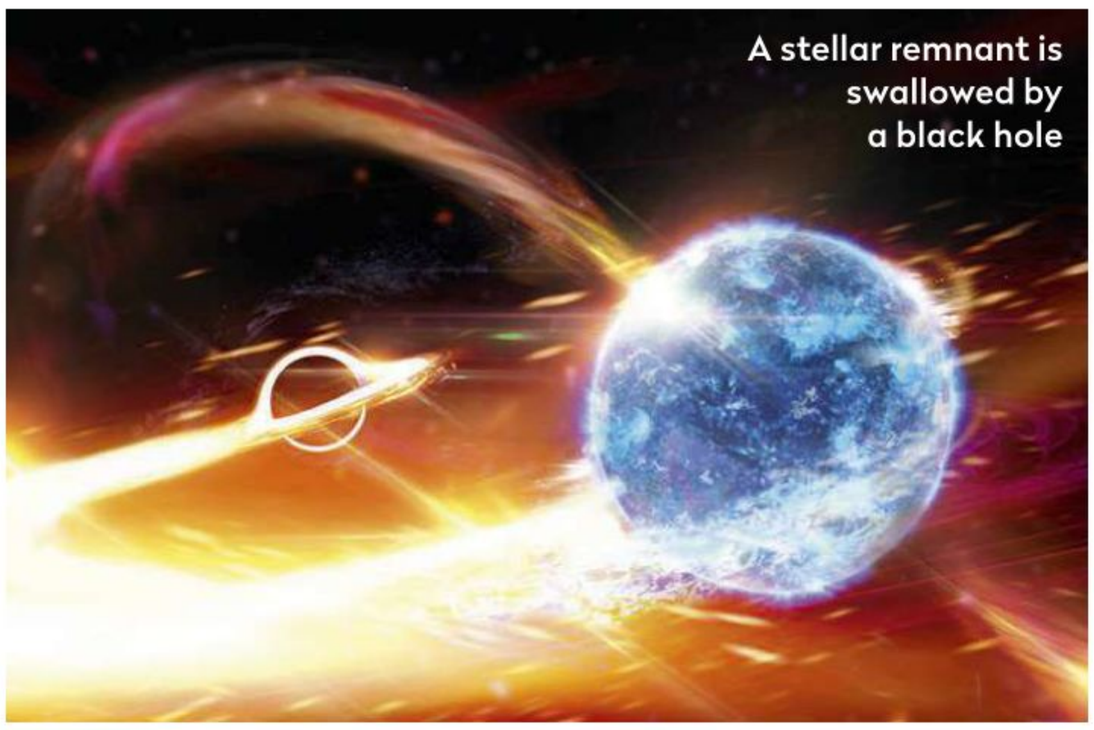
www.dur.ac.uk

Shockwaves as black hole devours neutron star

Astronomers have made the first ever detection of a black hole swallowing a neutron star. The event sent ripples through space and time that were recorded by two gravitational wave detectors, LIGO in the USA and Virgo in Italy, on 14 August.

In the following days, scientists were still trying to confirm the size of the two objects. The Australian National University's (ANU's) SkyMapper Telescope was unable to find any visual sign of the merger.

Professor Susan Scott, from the ANU Research School of Physics, says: "Scientists have never detected a black hole smaller than five solar masses or a neutron star larger than about 2.5 times the mass of our Sun.



A stellar remnant is swallowed by a black hole

"Based on this experience, we're very confident that we've just detected a black hole gobbling up a neutron star."

www.ligo.caltech.edu

NEWS IN BRIEF

Tardigrades invade Moon

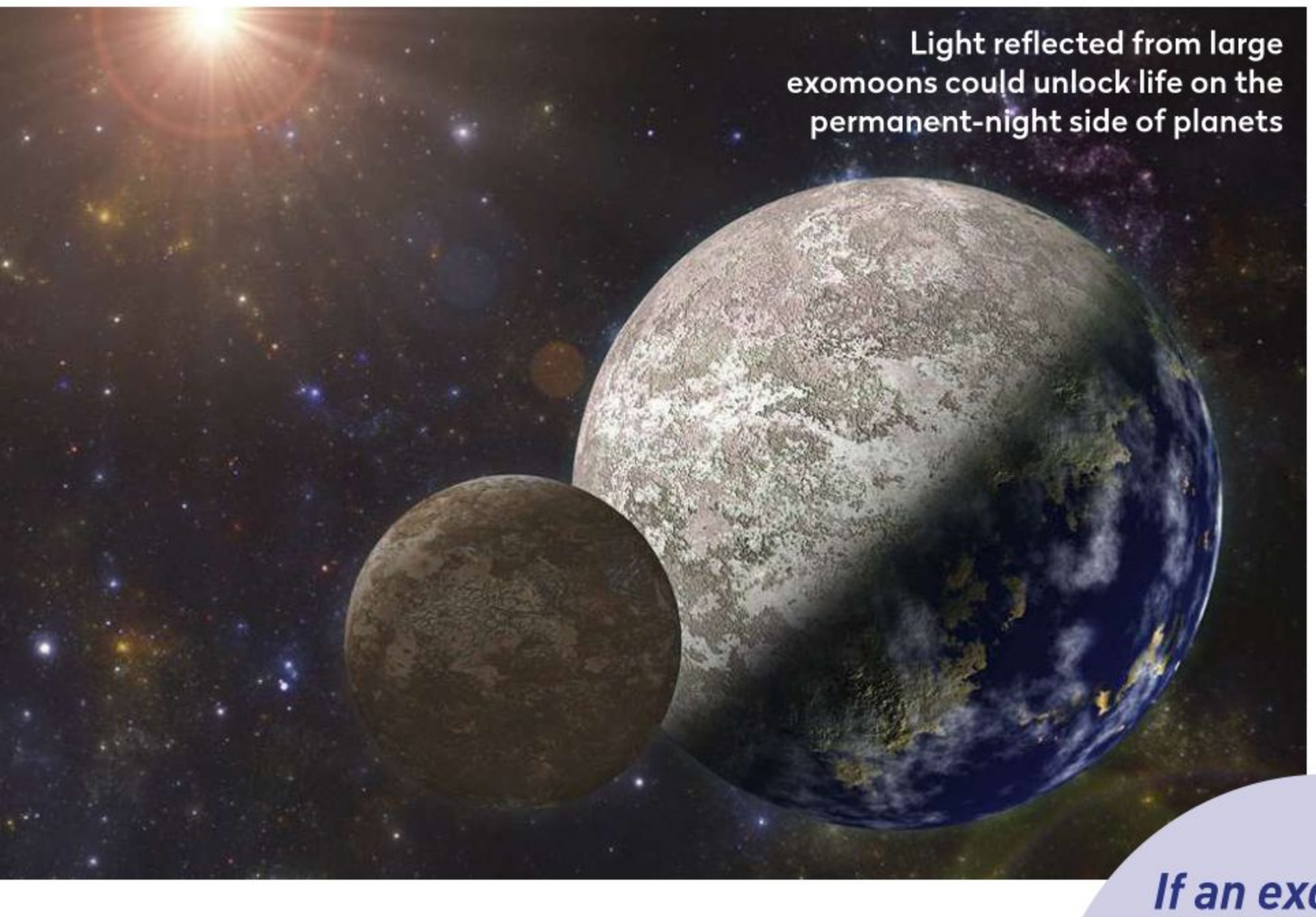
Israel's Beresheet spacecraft, which crashed into the Moon's Sea of Serenity in April, was carrying thousands of microscopic dehydrated tardigrades, it has been revealed. The news alarmed planetary protection supporters who warn against dangers of contamination. But the 'water bears' are unlikely to survive under harsh solar radiation and without water and an atmosphere.

Dead planet signals

Relics of planets orbiting white dwarf stars may still be detectable for up to a billion years from their radio signals, indicates research by the University of Warwick. White dwarfs have shed their outer layers, destroying all around them, but the magnetic field between the star and the planetary core acts as a conductor, according to Dr Dimitri Veras.

Four sites for Bennu

After studying asteroid Bennu's surface, scientists have picked four sites for NASA's OSIRIS-REx spacecraft to land and collect a sample. These are named Nightingale, Kingfisher, Osprey and Sandpiper. The probe is due to land in the latter half of 2020.


Light reflected from large exomoons could unlock life on the permanent-night side of planets

Can an exomoon make plants grow?

Tidally locked worlds may use moonlight to photosynthesise

M-class red dwarfs are by far the most common kind of star in the Milky Way, totalling around 75 per cent of all stars in our neighbourhood. Planets orbiting them probably represent one of the biggest categories of real estate for supporting extraterrestrial life. But these planets face one major potential problem for harbouring life: in order to receive enough warming to be habitable around such dim stars, a planet would need to be huddling very closely to the heat of its stellar campfire. And this proximity to their stars also means that such red dwarf worlds spin down to become tidally locked: their days are as long as their years and they have one face that experiences everlasting day and a far side in eternal night.

Assuming such a tidally locked world has a thick enough atmosphere to redistribute the stellar heat from the near side to the far, it could remain habitable. But what chances for an ecosystem on the dark side? Most surface life on Earth is directly or indirectly supported by photosynthesis – organisms like plants or cyanobacteria growing by capturing the energy of sunlight. So, could photosynthesis also power life on the night side of an M-dwarf exoplanet if it has a large enough moon to act as an orbiting reflector? Could a dark-side ecosystem be supported by moonlight? These questions have been raised by researchers Manasvi Lingam and Abraham Loeb at Harvard University.

Downside of the moon

Lingam and Loeb have calculated how bright the full moon would be under different exoplanet–exomoon scenarios, and therefore whether the flux of light would be enough to support photosynthesis. Assuming the albedo (reflectivity) of the exomoon is similar to our Moon, they worked out that photosynthesis is possible if the exomoon is larger than about one-tenth the size of Earth. This is a promising result for known exoplanets orbiting red dwarfs, such as Proxima b or the habitable planets around TRAPPIST-1.

If an exomoon is larger than one-tenth the size of Earth and of similar reflectivity to our Moon, photosynthesis is possible

But there's another problem, say Lingam and Loeb. The very tidal forces from the star's gravity that create a locked exoplanet in the first place also act to destabilise the orbit of any satellites – planets orbiting in the habitable zone of red dwarf stars are unlikely to have retained any large moons. So those planets most susceptible to becoming tidally locked, and so needing the reflected light from a moon to support photosynthesis on the permanent-night side, are unfortunately also the category of habitable planets most likely to have any large moons stripped away from them.

Prof Lewis Dartnell is an astrobiologist at the University of Westminster

So Lingam and Loeb also considered what is in effect the reverse situation: can photosynthesis be supported during night time on an Earth-sized exomoon orbiting a gas giant exoplanet by the sunlight reflected from the planet? In this case – not unlike the world imagined in the sci-fi film *Avatar* – the prospects actually seem much better. Their calculations revealed that there are situations where an Earth-sized exomoon can enjoy a habitable climate while also receiving enough reflected light from its gas giant host to power photosynthesis.

Lewis Dartnell was reading... *Photosynthesis on Exoplanets and Exomoons from Reflected Light* by Manasvi Lingam and Abraham Loeb.
Read it online at https://arxiv.org/abs/1907.12576

NASA/ESA AND G. BACON (STSCI), ELEN11/ISTOCK/GETTY IMAGES, HADZI3/ISTOCK/GETTY IMAGES, VADIM SADOVSKI/ISTCOK/GETTY IMAGES

Superfast star reveals secrets of Milky Way

Runaway star sheds new light on our distance from the Galaxy's centre

Prof Chris Lintott is an astrophysicist and co-presenter of *The Sky at Night*

Nearly five million years ago, when mammoths were just starting to roam Earth, a star called S5-HVS1 had a bad day. It had been minding its own business, living as one half of a binary system which had yet to stray far from the neighbourhood in which it had formed. As a normal A-type star, it was destined for a brief blaze of glory, a lifetime of a billion years or so shining as a bright blue-white component of its natal cluster.

S5-HVS1 and its as yet unidentified companion formed in the gas clouds in the middle of the Milky Way Galaxy. The binary passed close by the supermassive black hole that sits right at the centre itself, Sagittarius A* (Sgr A*). The gravitational dynamics are complicated, but when three bodies – in this case two stars and a black hole – interact, one can be expelled at high speed.

The massive star shot through the Galaxy for millions of years, before being noticed by astronomers at the AAT (Anglo-Australian Telescope) in Siding Spring, Australia. The researchers measured the star's speed at a cool 1,755 km/s (over 6 million km/h). It's hard to work out how a star could reach such a speed without tangling with the Milky Way's central black hole, and, when they traced back its path, it does seem to have come from that direction. In fact, its path traces back to the ring of bright young stars we observe around the black hole today, raising the possibility that its erstwhile companion might still be sitting there waiting to be discovered.

S5-HVS1 shows that a supermassive black hole can accelerate stars, a process first proposed 20 years ago

First of many

With new results from Gaia expected in a year or two, and new spectroscopic surveys of the sky planned, the star won't expect to keep its special status for too long; there should be dozens of similar stars within our grasp. Find enough of them and we might be able to begin to work out what the recent history of our neighbouring supermassive black hole has been. Flurries of stars might indicate episodes where the material around the central black hole has been disrupted, or when it was especially active. It's also possible the movements of other hypervelocity stars might help us trace the distribution of the mysterious dark matter that makes up most of the Milky Way's mass.

Though it's alone, we can learn from this single star. Just the fact that it exists says that a supermassive black hole can accelerate stars, a process first proposed 20 years ago but never before unambiguously observed. Fascinatingly, we can also use it to refine our understanding of the position of the Sun – if we assume it comes from the Galactic centre, then we can get a better measure of how far away we are. Because of this single star shooting past us, we now know we lie precisely 26,484 lightyears from the centre of our Galaxy. Not a bad legacy for a star that's just passing by.

S5-HVS1 has been speeding away ever since its dust-up with black hole Sgr A* 4.8 million years ago

Chris Lintott was reading... *The Great Escape: Discovery of a Nearby 1700km/s star Ejected from the Milky Way by Sgr A** by Sergey E Koposov et al.
Read it online at https://arxiv.org/abs/1907.11725

The Sky at Night TV show, past, present and future

INSIDE THE SKY AT NIGHT

▲ In the hot seat: 51 Peg b, a Jupiter-sized exoplanet that's 20 times closer to its star than Earth is to the Sun, has paved the way for discoveries

NASA/JPL-CALTECH, BBC X 2, BRITISH SCIENCE ASSOCIATION

In September's episode of *The Sky at Night*, the team spoke to **Dr Beth Biller** about how we might be able to track down Earth-like planets around other stars and the future of exoplanet hunting

On 6 October 1995, 51 Pegasi b became the first planet discovered orbiting a main sequence star outside our Solar System. 51 Peg b was surprising – unlike our own Solar System, where rocky planets like Earth and Mercury hug close to the Sun, and gas giants like Jupiter and Saturn lie much further out, 51 Peg b is a planet with a mass similar to Jupiter's but on an extremely close-in orbit. It's six times closer to its star than Mercury at its closest approach to the Sun, and 20 times closer than Earth is to the Sun.

Since then, astronomers have detected thousands of planets orbiting other stars. The diversity of these planets is staggering: not just hot Jupiters like 51 Peg b, but also super-Earths and mini-Neptunes: planets in between Earth and Neptune in size, as well as a handful of planets close to Earth's mass in the habitable zones of very low-mass stars. For now, our technology is most sensitive to planets in orbits close to their stars – our ability to detect Earth-like planets orbiting at Earth-like distances or to detect planets similar to Jupiter and Saturn remains quite limited. Most exoplanets have been detected either via the tug of the planet on its host star, or by the slight dimming of the star as the planet passes in front of it along our line of sight. Both of these techniques are strongly biased towards detecting close-in and massive planets. In fact, a hot Jupiter – like 51 Peg b is the easiest sort of planet for these techniques to detect.

In contrast, direct imaging – literally taking a picture of the planet itself – holds the potential to detect planets in wider orbits. The major limiting

Beth Biller is a reader in exoplanet studies at the University of Edinburgh

factor here is the overwhelming light from the star. However, with large telescopes and modern processing techniques, it is possible to overcome the huge contrast difference between the star and the planet. The handful of planets imaged directly to date are similar in mass and orbital distance to Jupiter, but are imaged at much younger ages, so these planets are much hotter than the gas giant. They have atmospheric temperatures similar to that of a candle flame since they are still warm from the energy of their own formation.

Anything with a temperature above absolute zero will be glowing at some wavelength. Very hot stars glow at optical (visible) wavelengths, whereas somewhat cooler young exoplanets will glow primarily at infrared wavelengths. Therefore, current telescopes work in infrared to directly image exoplanets. A very cold planet like Jupiter glows as well, but so faintly that it would be undetectable outside the Solar System – instead, Jupiter is visible from Earth due to the light it reflects from the Sun. Right now, direct imaging is limited to young, warm exoplanets – but with advances in technology and telescope size in the next couple of decades, images of analogues to Jupiter in reflected light will soon be within reach.

Looking back: The Sky at Night

October 1981

On 18 October 1981, Patrick Moore was joined on *The Sky at Night* by the recently retired Sir Bernard Lovell, who had been director of the Jodrell Bank Observatory near Manchester for 35 years.

Lovell started his career studying cosmic rays at the University of Manchester, but after World War Two found that the electrical interference from the city confounded his observations. He moved to the nearby countryside and set up the Jodrell Bank Observatory and began work on a new radio telescope. The scope would end up being 76m across and use turning mechanisms salvaged from World War One gunships. At the time it was the largest steerable telescope in the world.

Lovell navigated the project through financial woes and technical challenges, and the scope was completed in 1957. It tracked Sputnik 1, which was launched by the Soviet Union that October and became an instrumental facility during the Space Race. In 1987, it was renamed the Lovell Telescope, in honour of Sir Bernard. Lovell passed away on 6 August 2012, aged 98. Watch an extract from the episode here: **https://www.bbc.co.uk/programmes/p00ccmcg.**

▲ **Patrick interviewed Lovell on *The Sky at Night* about his telescope at Jodrell Bank**

The Sky at Night: Question Time

This month's episode sees Chris and Maggie join an expert panel for a Q&A session on the topic of space and astronomy. The event was filmed in front of a live studio audience at the University of Warwick on 13 September as part of the British Science Festival. Tune in to hear *The Sky at Night* presenters answer some of the biggest questions on the mysteries of the Universe.

BBC Four, 13 October, 10pm (first repeat **BBC Four, 17 October**, 7.30pm)
Check www.bbc.co.uk/skyatnight for subsequent repeat times

▲ **Join Chris Lintott and Maggie Aderin-Pocock for a cosmic Q&A**

Emails – Letters – Tweets – Facebook – Kit questions

INTERACTIVE

Email us at **inbox@skyatnightmagazine.com**

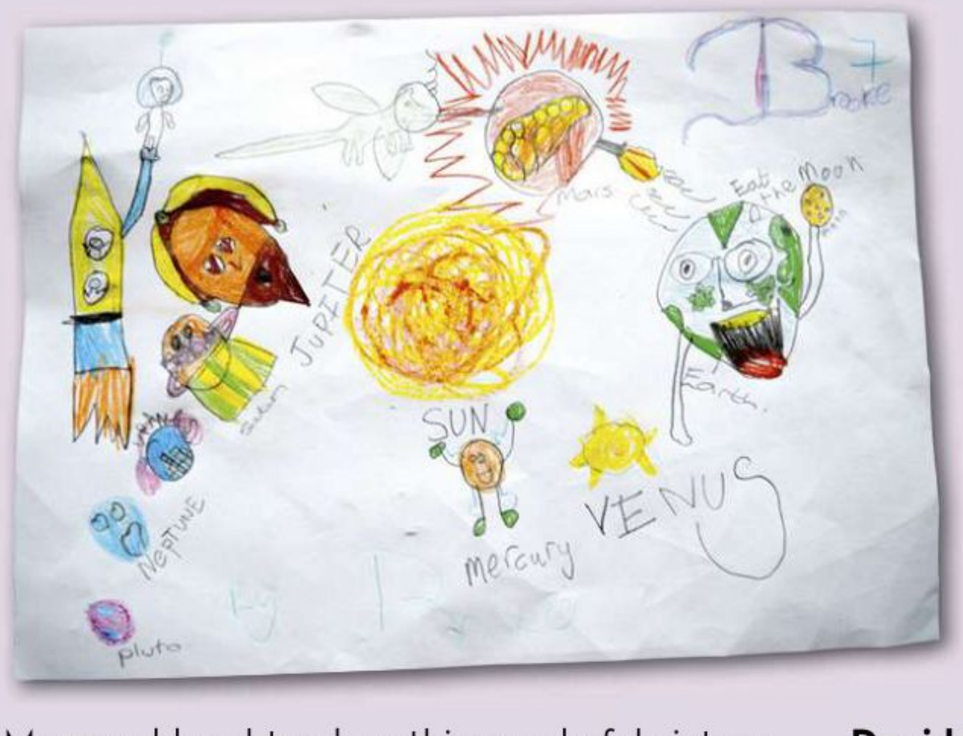
This month's top prize:
four Philip's books

PHILIP'S The 'Message of the Month' writer will receive four top titles courtesy of astronomy publisher Philip's: Robin Scagell's *Complete Guide to Stargazing*, Sir Patrick Moore's *The Night Sky*, Mark Thompson's *Stargazing with Mark Thompson* and Heather Couper and Nigel Henbest's *2020 Stargazing*.

Winner's details will be passed on to Octopus Publishing to fulfil the prize

MESSAGE OF THE MONTH

Playing with the planets



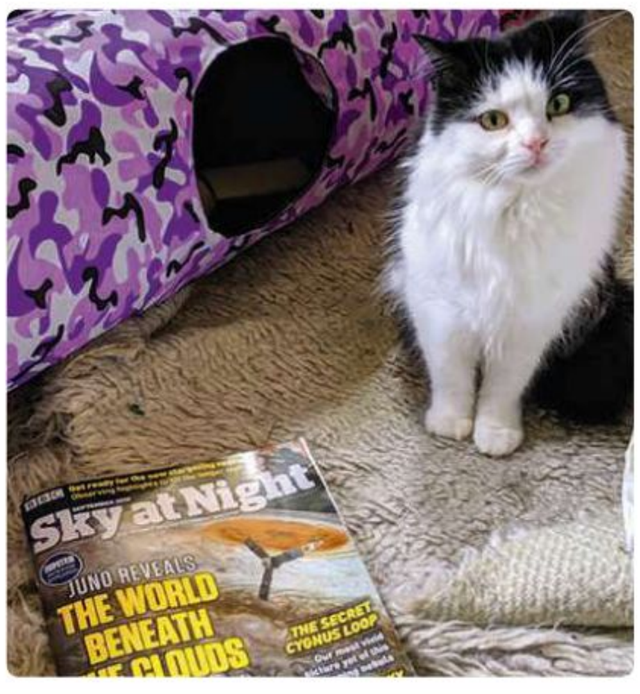
My granddaughter drew this wonderful picture: our Universe from the point of view of a seven year-old. While Pluto is pink and blue, Neptune is blue with mounds and Uranus is the DJ planet with headphones and a sound box. Saturn has a grass skirt and its rings are a hula hoop. Jupiter has four moons joined to make the face of the bad man in *Aladdin*. While Mars is being breathed on by a sun dragon and burnt with an upside-down volcano, Earth is eating the Moon, which is a giant chocolate chip cookie. Venus is a bright yellow star and Mercury is a muscle man holding up the Sun. There's also a rocket on its way to the Moon with a spaceman doing a walk. Brooke loves looking through my scopes and saw her first solar prominence last week.

David Booth, Northamptonshire

What a fabulous picture! It just shows how astronomy can capture young imaginations. Thanks for sharing it. **– *Ed***

Tweets

Stuart Atkinson
@mars_stu • 15 Aug
@JessRescueCat recommends the new issue of @skyatnightmag. She particularly enjoyed the features by @willgater and Katrin Raynor-Evans :-)



Captivating clouds

In the August issue of *Sky at Night Magazine* you mention it being a bumper year for noctilucent clouds (NLCs). It was a Friday evening in June, the 21st, and I was attending my local astronomy club, the Chesterfield Astronomical Society, when as the light faded a little there were some strange bluish clouds that seemed to be forming ripples. I rushed home after the meeting and took this picture out of my open bedroom window using a Canon EOS 1100D, just hand-held against the window frame. The NLCs were fascinating as they formed a vortex of ripples with the blackness above.

Sue Silver, via email

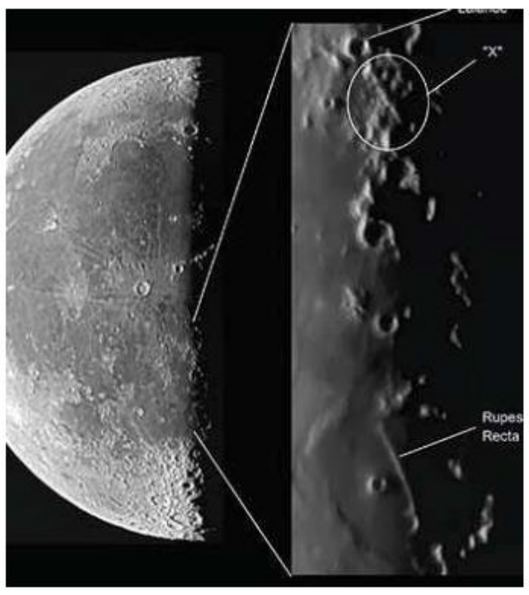
Conspiracy crusher

A huge thank you for Dallas Campbell's article (August 2019) debunking some of the Moon landing conspiracy theories. Hoisted out of bed by my mother at silly o'clock to watch a 'snowstorm' on a primitive rented black and white TV – and then, in my pyjamas, waving at the Moon from the back garden with my father – I have to say that it was a privilege to have been alive at that time to witness history. I was 10 and I worked out there and then, using long-multiplication on a very large piece of paper, how many inches it was to the Moon. I seriously doubt I could do that now. I was disappointed not to see Spock

or any Klingons though. I am deeply saddened by those who would seek to deny it ever happened – so more evidence please, so that we may continue to counter these silly conspiracies.
Margaret Bloomer, London

X factor

There are probably many clair obscur effects on the Moon – the Lunar X and V being two well-known examples – as the lighting changes dramatically from day to day. A few days ago, looking out of the window in the early hours of the morning, I saw the Moon at almost an exact last quarter phase. I thought I would use my 'Window-Sill Observatory' to image Rupes Recta (the Straight Wall) illuminated from



the 'other side' so that it appears as a bright line rather than its usual dark one. Studying the images (above) in detail, a little north of Rupes Recta and adjacent to the crater Lalande was another lunar X! Needless to say, these lighting effects are of no scientific interest, but interesting nevertheless.
Roger Samworth, Nuneaton ▸

ON FACEBOOK

WE ASKED: What's on your astrophotography bucket list?

Kate Gibbs
I'd love to be able to capture the Milky Way. I'm a beginner and I've ticked the Northern Lights off my list, so this is next for me!

Jonathan Demery
To visit the Southern Hemisphere and image the southern deep-sky objects.

Nick Williams
My 'triple crown' of a total solar eclipse, the Milky Way from a truly dark site and the Aurora. Two down, one to go.

Andy Smith
A showstopper comet. Surely we are due one soon?

Charlotte Daniels
Panel mosaics – the bigger the better!

Mick Cassidy
As a smartphone user, it has to be some deep-sky objects this winter to see what my phone camera can do. I've seen some serious images taken with mobile phones.

Jon Honey
I'm a total beginner so I don't have all the equipment yet, but the Milky Way, Horsehead Nebula and the Ring Nebula would be on my list.

Gerry Gee
Got myself a decent apo refractor at last. Some good filters would be the next treat!

Richard Newcombe
Getting the lights down so less light pollution. Then I can use my scope to start taking photos.

Tony Moss
Take a photo of as many of the planets as possible.

Dona Monroe
Finding a buddy to astro with!

Colin Teague
A cloud filter would be appreciated!

SCOPE DOCTOR

Our equipment specialist cures your optical ailments and technical maladies

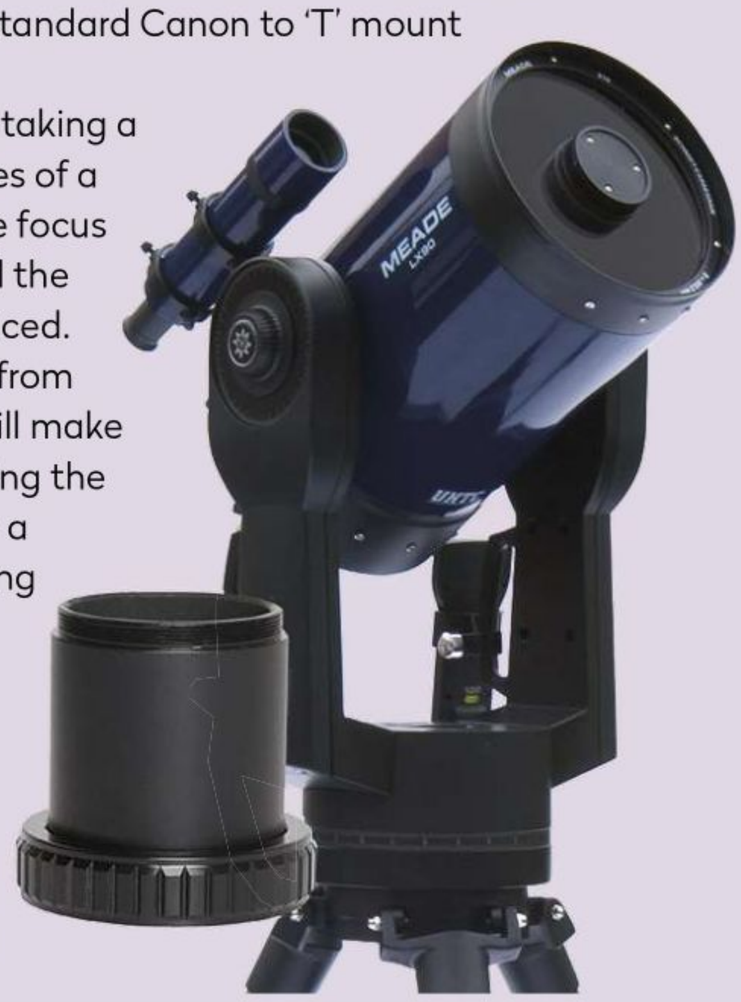
With **Steve Richards**

Email your queries to
scopedoctor@skyatnightmagazine.com

I'm having trouble focusing when using my Canon 1000D camera on my Meade LX90. Any advice?
PAUL LOMAS

The Meade LX90 is a Schmidt-Cassegrain telescope (SCT) mounted on a twin tine fork mount. This type of instrument has a visual back with a threaded mounting and a push-fit adaptor for attaching the star diagonal. For photographic use, the push-fit adaptor and star diagonal should be removed and a Meade Instruments 07352 No. 62 SLR Camera T-Adaptor screwed onto the visual back in its place. To mount the Canon 1000D onto the adaptor, a standard Canon to 'T' mount adaptor will be required.

Focus is best achieved by taking a series of 10-second exposures of a bright star and adjusting the focus position between shots until the smallest star image is produced. A Bahtinov mask, available from most astronomy retailers, will make this task even simpler. Viewing the captured images directly on a laptop computer screen, using the EOS Utility software supplied with your camera, will make the task easy and comfortable.



▸ **Perfect pair: try using a Camera T-adaptor with a Meade LX90**

Steve's top tip

What is flocking?

It is important to stop internal reflections within a telescope in order to avoid any loss of contrast, which is why telescopes have a matt black interior. However, the paint that's used is rarely completely non-reflective or pure black.

Lining the inside of the telescope tube with black flocking material is a very effective way to kill unwanted reflections, as stray light is absorbed by the rough and very black surface. If you remove the eyepiece and dust cover and look through the focus tube, every surface that you can see (with the exception of the mirrors) should be covered with flocking material.

Steve Richards is a keen astro imager and an astronomy equipment expert

BBC Sky at Night MAGAZINE

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Is it the ISS?

▸ I have always wanted to photograph the ISS but found it difficult to track with my 200mm Sky-Watcher telescope. But one evening I captured this shot – not very good you might say, but when I tell you that it was taken with my Nikon DSLR and 300mm lens, with a tracking, hand-held single shot, it's amazing I got anything! It was a dot on the frame, but after cropping I have the picture you see. The two bright stripes I assume are the solar panels. It was taken at 1/500th second, 600 ISO. I think it proves you can capture some good shots even without a telescope.
Bill Ritter, Tewkesbury

Lovell fireworks

I was pleased to hear that the iconic Lovell Telescope joined the list of UNESCO World Heritage sites in July. To celebrate this, I climbed a local hill to take some images of the dish while it was lit up for the Blue Dot festival. To my surprise, it was joined by a firework display. It looks like I was not the only one to celebrate over 60 years of radio astronomy at Jodrell Bank.
Alan Hodgson, Bollington, Cheshire

Tweets

Anna St George
@Annacreegan • 4 Aug
I love #Perseids season! We get the camp beds and light a small fire in the garden. @skyatnightmag @BBCStargazing

SOCIETY IN FOCUS

The Northamptonshire Natural History Society was delighted to welcome Dr Mike Leggett FRAS (pictured left) for his talk on the Apollo programme on 29 July, just one of many guest speaker talks we enjoy through the year.

Apollo was not only a significant milestone in the exploration of space and a great technical achievement, but also sparked the imagination of a whole generation. As a 12 year-old I was glued to the TV, watching reports of Apollo 8 as it circled the Moon in 1968. All these years later, following a lifelong interest in astronomy, I can trace my original inspiration back to these NASA missions.

Dr Leggett started his talk with details of the early unmanned missions to the Moon and then included the Gemini series that led up to Apollo. He credited John C Houbolt as a leading engineer and champion of the Apollo lunar orbit rendezvous proposal. He also detailed each

Apollo mission, from tragedy to ultimate triumph, and how these helped humanity's understanding of the formation of the Moon and planetary science. Dr Leggett also outlined the Skylab and Apollo-Soyuz projects that were built on the technology developed for Apollo. Along with his display of memorabilia from the time – books, newspapers and the like – this was an enjoyable and interesting evening.
Dr Steve Arnold, astronomy secretary, Northamptonshire Natural History Society
▸ **ww.nnhs.info**

YOU'RE GOING TO NEED A BIGGER FRAME

QSI are proud to announce a new large format camera, the QSI-6162. This features the mighty KAF-16200 CCD sensor, produced specifically for astrophotography. The larger case accommodates the 16MP sensor and 2" filters, with the same high quality QSI electronics. Options include an off axis guider and a choice of a 5 or 8 position filter wheel, for the complete astrophotography solution.

Now available to order. If you want quality, you want QSI.

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The indicated edges of a lunar crater surrounding the lens finish the look.

www.segatoys.space 149GBP

Our pick of the best events from around the UK

WHAT'S ON

York star party

Knavesmire Road, York, 3 & 31 October, 7pm

Take part in a free public star party hosted by York Astronomical Society. The evening will involve stargazing through telescopes and equipment is provided, but you can also bring your own.

yorkastro.org.uk/knavesmire/

Astronomy evening class

Stirling Highland Hotel Observatory, Stirling, 3 October, 7pm

Join Stirling Astronomical Society for one of their evening classes, open to anyone over 11 years old. The classes are run once a month on Thursday evenings.

www.stirlingastronomicalsociety.org.uk/Meetings.html

Beginners' open evening

Bromsgrove Rugby Club, Bromsgrove, 7 October, 7pm

Experienced astronomers and newcomers are invited to an event hosted by Bromsgrove Astronomical Society, featuring an introduction to stargazing, an astrophotography workshop and observing through telescopes. Admission is free.

www.broms-astro.org.uk

Autumn Milky Way highlights

Glenlivet Public Hall, Bridgend of Glenlivet, 19 October, 8pm

Join members of the Tomintoul and Glenlivet Landscape Partnership and discover the highlights of the Milky Way against the backdrop of the Orionids meteor shower.

www.darkskies.glenlivet-cairngorms.co.uk/events/

PICK OF THE MONTH

▲ **Winning form: visit the exhibition that showcases the world's finest astro images**

Insight Investment Astronomy Photographer of the Year 2019

National Maritime Museum, Greenwich, London, 13 September 2019 – 26 April 2020

The world's biggest astrophotography competition returns for 2019, this year with a public display at the National Maritime Museum showcasing 100 of the winning and shortlisted images.

During the exhibition, visitors will also get the chance to vote for their own favourite photo in the People's Choice award category.

IIAPY is the world's biggest astrophotography competition and welcomes images from across the globe in categories including: Aurorae; Our Sun; Our Moon; Planets, Comets and Asteroids; Stars and Nebulae; and Galaxies. There are also prizes for best newcomer, best young astronomy photographer and astro images captured remotely via robotic scope.

Tickets for this year's exhibition are £10 for adults and £5 for children. The exhibition is open daily from 10am until 5pm. Advance bookings (with discounts) can be made via the IIAPY website.

www.rmg.co.uk/whats-on/astronomy-photographer-year/competition

Deep-sky lecture

Technium 2, Swansea, 24 October, 7pm

Learn about deep-sky observing in the constellation of Cassiopeia with Swansea Astronomical Society. Non-members are welcome. For more information visit the society's website. **www.swanastro.org.uk/memberevents.php**

Toothill open evening

Toothill Observatory, Southampton, 25 & 26 October, 7.30pm

Join Solent Amateur Astronomers as they open their observatory for an evening of stargazing. Entry costs £2 for adults, 50p for children and it's free for members.

www.solentastro.org/eca2.html

YORK ASTRONOMICAL SOCIETY, NATIONAL MARITIME MUSEUM/LONDON

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BBC Sky at Night MAGAZINE

The amateur astronomer's forum

FIELD OF VIEW

We're all going on a nightwalk

Writer **Tiffany Francis** reveals how her stargazing excursions have enhanced her appreciation of nature's hidden wonders

Nature writer **Tiffany Francis** stargazes from her home in the South Downs. Her new book, *Dark Skies: A Journey into the Wild Night*, is out now

The first time I discovered nightwalking was when my boyfriend was away on tour with his band. Not usually a poor sleeper, I would struggle to drift off without the comfort of knowing he was home, so to clear my head and encourage peaceful thoughts I would make a flask of mint tea, hop in the car and drive to Butser Hill, a favourite spot near my home in the South Downs National Park. Leaving the car parked, I would hike through elder trees and hazel copse, stumble over rabbit warrens and jump over cowpats until I was alone on the summit beneath a veil of stars cascading over Hampshire and Sussex.

On the far side of the hill, an Iron Age burial mound lay strewn with mosses and wildflowers, polo-shaped and facing away from the sea. I would climb into the mound and lie down with my back propped against the soil, dirt and dock leaves pressed against the palms of my hands, no doubt disrespecting some ancient soul buried beneath me. Sipping hot tea in my hidden corner of the world, I'd spend an hour watching each constellation tell its tale on the midnight stage, foxes barking in the trees behind me and fresh night air filling my lungs.

Stephen Hawking once invited us to "Look up at the stars and not down at our feet", and in our anthropocentric, pressurised world, gazing out into the Universe can help our daily problems and worries feel insignificant. At the same time, it can empower us to remember that a precise cluster of atoms came together to form our exact minds and bodies, reminding us how lucky we are to be alive on Earth.

I spent a year travelling around the UK and Europe in order to understand our relationship with the night sky. As the months passed and seasons changed, I learnt to observe the shifting hours of sunsets and sunrises, becoming more in tune with my circadian rhythm and appreciating the joy of first light and the velvet beauty of nightfall. In winter, although the days were short and cold, the nights drew in early and allowed me to catch a glimpse of the stars before bed. In summer the evening air was balmy and sweet, full of churring nightjars, hunting owls and sparkling glow worms in the countryside's long grass.

The modern world means our sleeping patterns have adapted to suit office hours and school runs, but that doesn't mean we can't try to synchronise more closely with our natural rhythms. To venture out into the wilderness after nightfall is a natural behaviour we can all benefit from and, in doing so, landscapes that were once familiar to us transform into unearthly spaces. In savouring the unknown we are offered new territories to explore and new ways to connect with nature. Just as Lord Byron wrote in his poem *Manfred*, at night we can "learn the language of another world".

HIFU MIYO/FOLIO ART

BBC

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BBC Sky at Night MAGAZINE

Insight Investment

Astronomy Photographer of the Year

BBC Sky at Night magazine can proudly reveal the 2019 winners of the world's largest astrophotography competition

OVERALL WINNER / OUR MOON

Into the Shadow

László Francsics (Hungary)

Photo location: Budapest, Hungary, 21 January 2019

Equipment: 250mm Newtonian telescope at f/4, Sky-Watcher EQ6 Pro mount, Sony Alpha 99 camera, HDR composite of multiple exposures

Judge's verdict: "For a single multiple-exposure image to capture this event with such positional precision, creative innovation and beauty is nothing short of masterful. The colours of our atmosphere projected onto the Moon's disc during the eclipse are not only artistically pleasing, but also offer an understanding of such events and can reveal aspects of our own thin, yet essential, atmosphere. In a year that celebrates 50 years since the first lunar landings, it is fitting that this year's overall winning image captures such a dynamic and captivating view of our Moon. A worthy winner indeed."
– Ed Robinson ▸

More **ONLINE**
A gallery of these and more stunning images from the competition

AURORAE

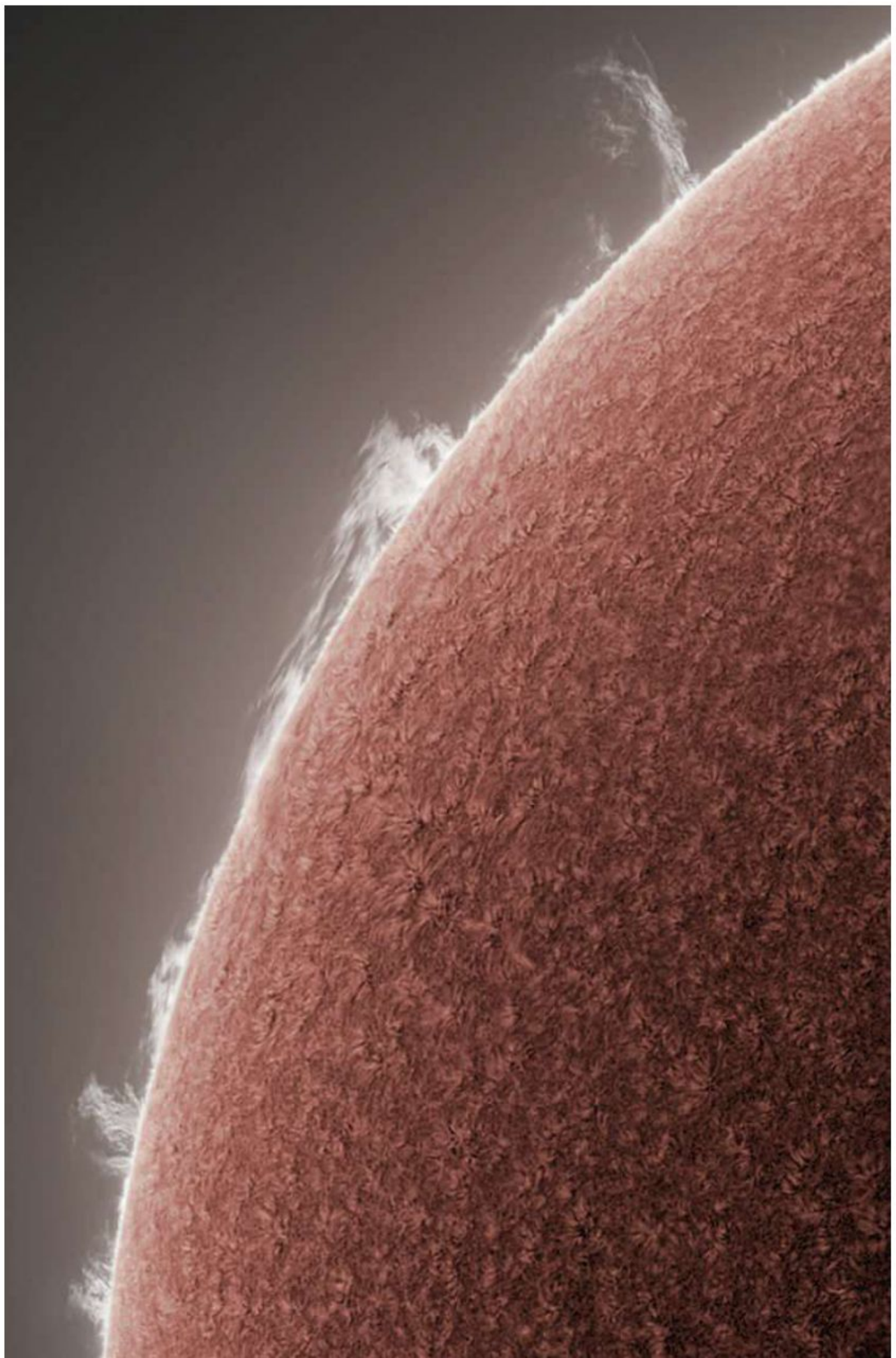
△ The Watcher

Nicolai Brügger (Germany)
Photo location: Lofoten, Norway, 9 March 2018
Equipment: Nikon D600 camera, 15mm f/2.8 lens, ISO 2000, 12x13-second exposures
Judge's verdict: "To me this picture is about the interplay of celestial, terrestrial and human light – the Milky Way, the wavy aurora, sprawling city lights in the distance, the snow and sea reflecting the ambient glow. The sense of depth is astonishing."
– Melanie Vandenbrouck

OUR SUN

A Little Fireworks ▷

Alan Friedman (USA)
Photo location: Buffalo, New York, USA, 29 July 2018
Equipment: Astro-Physics Stowaway 90mm apochromatic refractor telescope at f/20, Coronado SolarMax 90mm etalon filter, Astro-Physics German equatorial mount, Point Gray Research Grasshopper camera, 33-millisecond exposure
Judge's verdict: "The use of a different colour palette to our expectations gives us an alternative way to think about the Sun." **– Alan Sparrow**



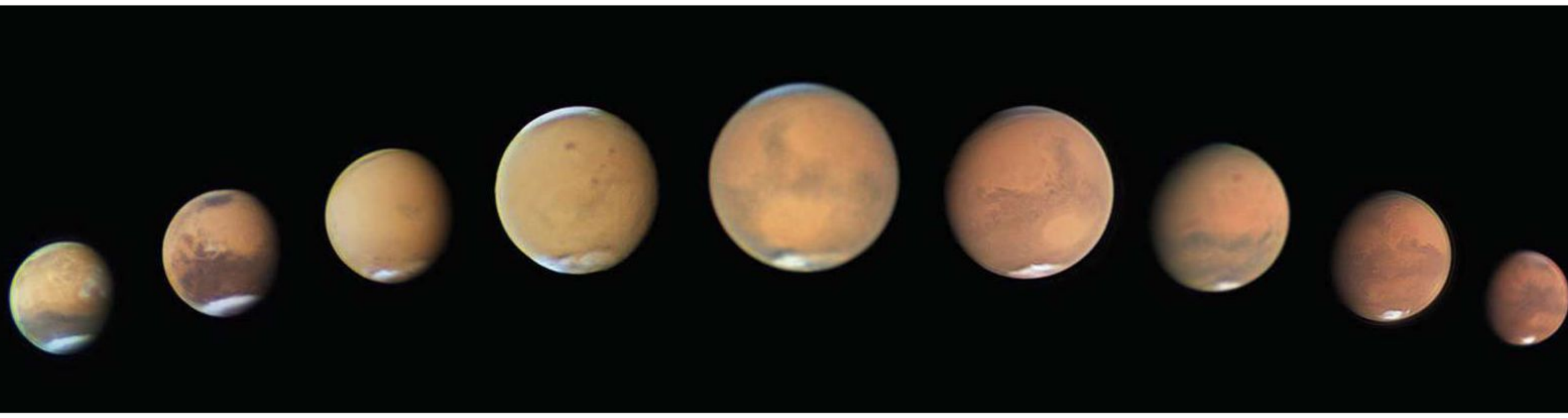
SIR PATRICK MOORE PRIZE FOR BEST NEWCOMER (JOINT WINNERS)

△ The Jewels of Orion

Ross Clark (UK)
Photo location: Embleton, Northumberland, UK, 30 January 2019
Equipment: Canon 450D astro-modified camera, Sky-Watcher Star Adventurer mount, Canon EF 70–200mm f/2.8L USM lens at 200mm f/3.5, ISO 800, two-panel mosaic, 3-hour total exposure
Judge's verdict: "A marvellous image that captures the way we often see the Universe in our imagination: families of stars, clusters, nebulae and myriad points of detail. It's incredible to think that such an image comes from a newcomer." **– Jon Culshaw**

Sky and Ground, Stars and Sand ▷

Shuchang Dong (China)
Photo location: Ningxia, China, 25 July 2018
Equipment: Canon EOS 5D Mark IV camera, 50mm f/1.8 lens, ISO 250, 60x25-second exposures
Judge's verdict: "A mesmerising illustration of the night sky's natural light; the dune sea promises a limitless horizon, yet the stars across the Universe outnumber its grains many times." **– Tom Kerss**



PLANETS, COMETS AND ASTEROIDS

△ Death of Opportunity

Andy Casely (Australia)
Photo location: Sydney, Australia, 26 May–30 October 2018
Equipment: Celestron C14 355mm Schmidt-Cassegrain reflecting telescope at f/26, Astronomik RGB filters, Celestron CGX-L mount, ZWO ASI290MM camera, mosaic of multiple stacked exposures
Judge's verdict: "The loss of the Mars Rover Opportunity pulled at the heartstrings of many observers. Having exceeded its lifespan by some 14 years... to end its life in a dust storm seemed a cruel blow. But what a dust storm! It's clear to see why Oppy didn't stand a chance." **– Mandy Bailey** ▸

PEOPLE AND SPACE

Ben, Floyd and the Core ▷

Ben Bush (UK)
Photo location: Hadrian's Wall, Hexham, UK, 9 August 2018
Equipment: Nikon D810 camera, 24mm f/1.4 lens, ISO 4000, 10-second exposure
Judge's verdict: "Talk about a 'decisive moment!' Vast yet intimate, breathtaking and touching all in one beautiful image." **– Oana Sandu**

STARS AND NEBULAE

◁ Statue of Liberty Nebula

Ignacio Diaz Bobillo (Argentina)
Photo location: General Pacheco, Buenos Aires, Argentina, 24 March 2018
Equipment: Astro-Physics 167mm apochromatic refractor telescope at f/7.2, Astrodon SII, H-alpha, and OIII 3nm filters, Astro-Physics 1100GTO mount, Apogee Atlas U16M camera, narrowband, SII-Ha-OIII composite, 16-hour total exposure
Judge's verdict: "The choice of palette and attention to colour balance lend a fairy-tale quality to this image. Pools of light are perfectly balanced, inviting the eye to explore the abstract sculptural beauty of the nebulae. A superb result." **– Tom Kerss**

YOUNG ASTRONOMY PHOTOGRAPHER OF THE YEAR

Stellar Flower ▷

Davy van der Hoeven, aged 11 (Netherlands)
Photo location: Hendrik-Ido-Ambacht, South Holland, Netherlands, 26 February 2019
Equipment: TMB92SS 92mm apochromatic refractor telescope at f/5.5, Sky-Watcher NEQ-6 mount, QSI 583ws camera, Ha-OIII-SII composite, 16 hours 15 minutes total exposure
Judge's verdict: "The quality and detail of the final image are simply stunning, considering the experience that photographers in this category have. If 11 year-olds are so interested in space they are willing to put in the time and effort to produce such images, I can only be optimistic not just about the astronomy of the future, but science and technology in general." **– Oana Sandu**

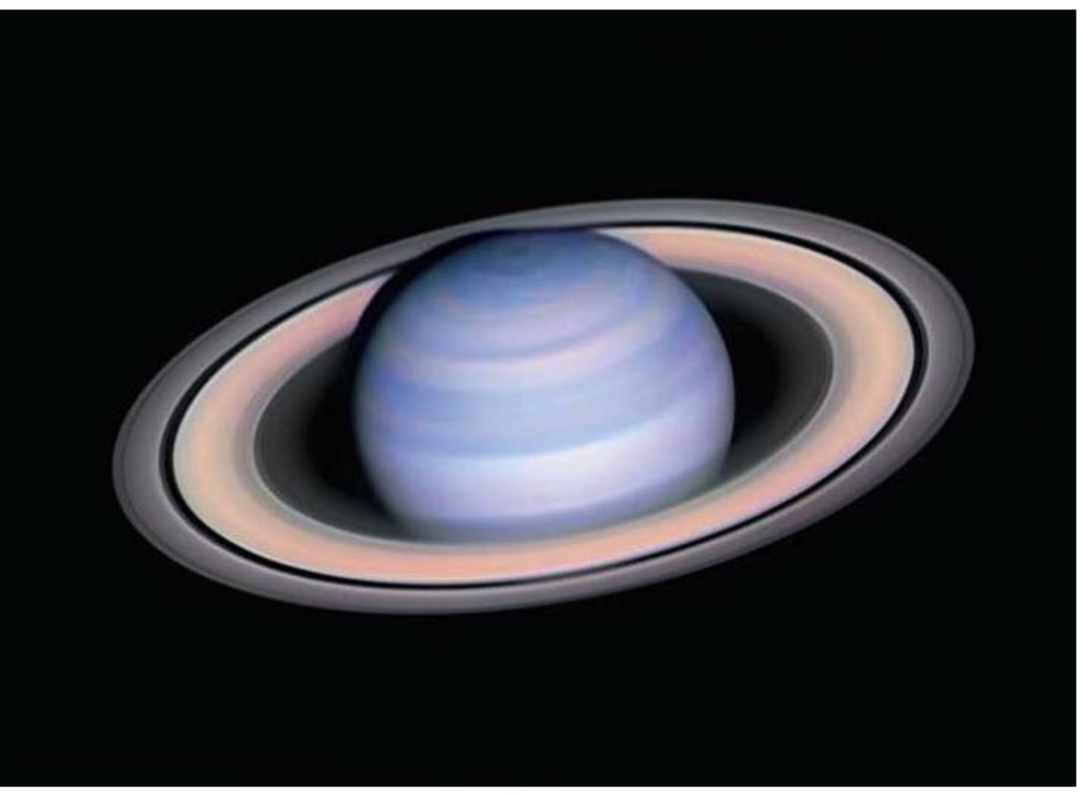
GALAXIES

Shells of Elliptical Galaxy NGC 3923 in Hydra ▷

Rolf Wahl Olsen (Denmark)
Photo location: Auckland, New Zealand, 21 May 2017–25 March 2018
Equipment: Homebuilt 12.5" Serrurier Truss Newtonian telescope at f/4, Losmandy G-11 mount, QSI 683wsg-8 camera, L-RGB composite, 41 hours 38 minutes total exposure
Judge's verdict: "What a gem this image is. The concentric shells are reminiscent of the rings that show the age of a tree. A galaxy with a ring system, a Saturn galaxy! All with the hue of sunlight during the golden hour on Earth." **– Jon Culshaw**

ROBOTIC SCOPE

◁ Infrared Saturn



László Francsics (Hungary)
Photo location: Chilescope, Atacama region, Chile, 26 August 2018
Equipment: Chilescope T1 ASA 1000mm Ritchey-Chretien reflecting telescope at f/16, Baader R, IR 685, IR 742 filters, Alt-azimuth fork mount, ASI 174MM camera, R-IR composite, multiple stacked exposures
Judge's verdict: "Colourful, abstract, creative and accomplished. I commend the photographer for their exploration and experimentation into colour and light to reveal a spectacular view of Saturn, one that I have never seen in this way before. An inspirational use of a robotic scope and a reminder to amateurs that it's a great and accessible tool to push your imaging, techniques and creativity further." **– Ed Robinson**

SKYSCAPES

Across the Sky of History ▷

Wang Zheng (China)
Photo location: Ejina, Inner Mongolia, China, 12 August 2018
Equipment: Canon EOS 5D Mark IV camera, 20mm f/2 lens, ISO 6400, 10-second exposure
Judge's verdict: "From the movement of the trees to the streak of the meteor there is symmetry and drama in this shot that feels like it was always there. The decision to desaturate the image gives it an ageless feel." **– Steve Marsh** ▸

Insight Investment

Astronomy Photographer of the Year

The world's greatest astrophotography competition continues to inspire

For 11 years the Insight Investment Astronomy Photographer of the Year has been the premier competition for astrophotographers. In 2019, the competition received 4,600 entries from 90 different nations, submitted by photographers of all ages and abilities. It was no easy feat to decide which image would be crowned the victor and win the £10,000 top prize.

You can see the competition's best images – including the overall winner – for yourself by visiting the National Maritime Museum, where they'll be on display in a fabulous new exhibit from 13 September 2019 until 26 April 2020. If the images on the last few pages have inspired you to get involved, then visit **www.rmg.co.uk/astrophoto** for more information.

THE JUDGES

Mandy Bailey
Astronomy Secretary for the Royal Astronomical Society.

Jon Culshaw
Comedian, impersonator and regular guest on *The Sky at Night*.

Tom Kerss
Observatory Science Communication Officer at Royal Museums Greenwich.

Steve Marsh
Art Editor at *BBC Sky at Night Magazine*.

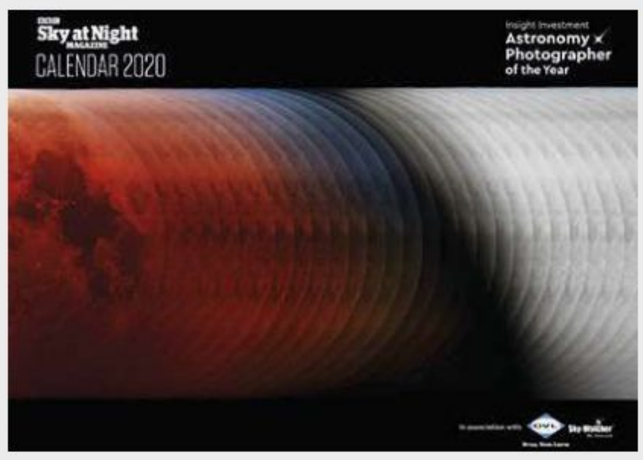
Ed Robinson
Award-winning photographer, creative director and visual consultant.

Rebecca Roth
Photographer, Image Coordinator and Social Media Specialist at NASA's Goddard Space Flight Center.

Oana Sandu
Community Coordinator for the European Southern Observatory.

Alan Sparrow
Director of Fleet Street's Finest and Chair of the UK Picture Editors' Guild.

Melanie Vandenbrouck
Curator of Art (post-1800) at Royal Museums Greenwich.



Free 2020 calendar

The December issue of *BBC Sky at Night Magazine* comes with a free 2020 calendar featuring some of the top images from the Insight Investment Astronomy Photographer of the Year 2019 competition. It goes on sale 21 November.

The winners of this year's competition will be displayed at the National Maritime Museum, London

BBC Sky at Night MAGAZINE

EASY ASTRO PHOTOGRAPHY

BACK GARDEN ASTRONOMY WEEK

28 SEP – 04 OCT

Discover the wonders of the night sky one simple step at a time – we'll make it easy!

Have you always wanted to discover the night sky but just don't know where to start? If so, then **Back Garden Astronomy Week** is for you!

Launching at the end of September, *BBC Sky at Night Magazine* will introduce the wonders of stargazing in easy-to-do, nightly observing instalments.

Just sign up and each day from **Saturday 28 September – Friday 4 October** we'll send you a no-nonsense email newsletter that will help you discover a new sight every night.

We'll show you how to find magical objects in the night sky, and we'll give you an easy introduction to astrophotography, helping you capture what you see with a smartphone or DSLR camera.

You don't need to travel far to find beguiling star clusters, bright planets and even distant galaxies beyond our own.

Each day during **Back Garden Astronomy Week** you'll also receive essential observing and astro imaging tips to get the most out of stargazing and night-sky photography.

We offer advice about how to avoid camera shake, the right smartphone apps for low-light conditions and which accessories are the best for photographing the night sky.

Sign up today to kickstart your journey of discovery to the stars and we'll send you a **free 58 page digital starter pack!**

FREE
58-PAGE DIGITAL STARTER PACK AND ASTROPHOTOGRAPHY GUIDE

Sign up today!

► Visit **www.skyatnightmagazine.com/backgarden** to sign up in a few easy steps

BACK GARDEN ASTRONOMY WEEK

28 September – 4 October

CAPTURE THE STARS

Along the Milky Way

As the Milky Way arches right overhead at this time of year, **Paul Money** guides you to some of its most arresting sights

Our Galaxy, the Milky Way, is a treasure trove of targets and conveniently at this time of year arches overhead across the sky, making the season ideal for casual and more detailed viewing. Beginning in the south southwest, with targets that will be the first to slip below the horizon, over the following pages we'll tour the whole arch of the heavens, highlighting some of the best sights to see with the naked eye, binoculars and a telescope. So find somewhere with an uncluttered horizon and get ready to tour along the Milky Way.

Why not frame the majesty of the Milky Way with a striking landmark?

The south southwestern sky: Sagittarius to Aquila

1. JUPITER, THE GIANT PLANET

Jupiter dominates the evening sky low in the south southwest as twilight fades. To the naked eye it looks like a bright star, but use 10x50 binoculars and you should spot its disc and even its four Galilean moons. These will change position night after night so keep a check on them as they orbit the planet. Using a telescope, look for the two main bands either side of Jupiter's equator and you may even spy the Great Red Spot.

2. SATURN, THE RINGED PLANET

Although smaller than Jupiter and farther away, Saturn has a special charm due to its bright ring system. To the naked eye it looks like a pale yellow star, but large binoculars may allow you to spot its largest moon, Titan. A scope reveals the planet's ringed nature and you may be able to spot the Cassini Division separating the outer A ring from the B ring, plus a dusky northern belt and slightly darker polar hood on the planet's disc. The glare of the planet makes the inner moons harder to spot.

3. THE LAGOON AND TRIFID NEBULAE, M8 & M20 (PLUS THE M21 CLUSTER)

This trio of objects lies roughly between Jupiter and Saturn in our view from Earth, but they are actually located outside the Solar System, towards the Galaxy's centre. The Lagoon Nebula, M8, is a

▲ **The area around Jupiter's Great Red Spot has been showing plenty of activity this year**

star-forming region that looks like a small cloud through binoculars. To its north lies the Trifid Nebula, M20, but the nebulosity is much harder to spot and really requires a scope. To the northeast of M20 is a small cluster, M21, which is often overlooked, yet it's a nice little object to observe in a telescope.

4. GLOBULAR CLUSTERS M22 & M28

With a pair of binoculars, locate the naked eye star Lambda (λ) Sagittarii to the east and a fraction south of M8. Saturn is close by but before you get to it, you'll see a hazy spot in the stars to the upper left – this is the large globular cluster M22. Meanwhile, a smaller globular, M28, lies to the northwest of Lambda; see if you can spot a similar haze in binoculars there too.

5. SMALL SAGITTARIUS STAR CLOUD (M24), AND CLUSTERS M25 & M23

Move higher on the Milky Way's centre disc and to the naked eye there is a hazy cloud north of the star Mu (μ) Sagittarius. This is the Small Sagittarius Star Cloud, M24, and is prominent if you have clear dark skies. You can use it to seek out two open star clusters, M23 and M25: the first is off to the west and the second to the east.

6. M16, M17 AND M18

Just north of M24 lies an often overlooked star cluster, M18, which is small but viewable as a hazy spot in binoculars. Sweep north from here to take in the Omega Nebula, M17, a nice nebulous patch shaped a bit like a tick mark in a small scope. In 7x50 binoculars there is a second nebulous spot a bit further north, M16.

7. WILD DUCK CLUSTER, M11

Look northeast of Scutum for Lambda (λ) Aquilae, one of the lowest stars in the Aquilla constellation. Along with four other stars to Beta (β) Scuti they form what looks like a fish hook on its side. Look below Beta (β) Scuti and Eta (ε) Scuti for a small cloud of stars. This is the Wild Duck Cluster (M11), resembling a flight of ducks in a 'V' formation. ▸

ROB STILLWELL/WWW.CASUALSNAPPER.COM, D.PEACH/CHILESCOPE TEAM, CHART BY PETE LAWRENCE

The zenith sky: Aquila to Cygnus

1. SUMMER TRIANGLE

We now move steadily north along the Milky Way and look with the naked eye for a bright triangle of stars, the Summer Triangle. Consisting of Deneb in Cygnus to the northeast, with Vega in Lyra northwest and then Altair in Aquila in the south, it is very prominent for a large part of the year, but especially late summer and autumn when it is high in the evening sky. While Altair and Vega are relatively nearby at 17 and 25 lightyears, Deneb must be very bright as it is put at 1,500 lightyears away.

2. CYGNUS RIFT

As you gaze at the Summer Triangle something else becomes apparent if you have clear dark skies: there appears to be a 'gap' in the milky band of the Milky Way running down the east side of Cygnus with fewer stars. This is the Cygnus Rift, part of the 'great rift' of dark obscuring dust that lies along the plane of our Galaxy. It is amazing to think that you can see a 'dark' object at night, but this is only thanks to the glow of stars behind it being hidden from view.

3. COATHANGER CLUSTER

Look for an arrow-shaped group of stars to the southeast of the end star of Cygnus, Albireo – a stunning double star in a scope. This is Sagitta 'the Arrow' and just to its west lies a smudge of light that looks like an upside down coathanger in binoculars, hence the common name of the Coathanger Cluster. Also known as Collinder 399, this is over 1.5° wide and looks even better in a rich field scope.

▼ See if you can make out the group of stars that form the distinctive Coathanger Cluster

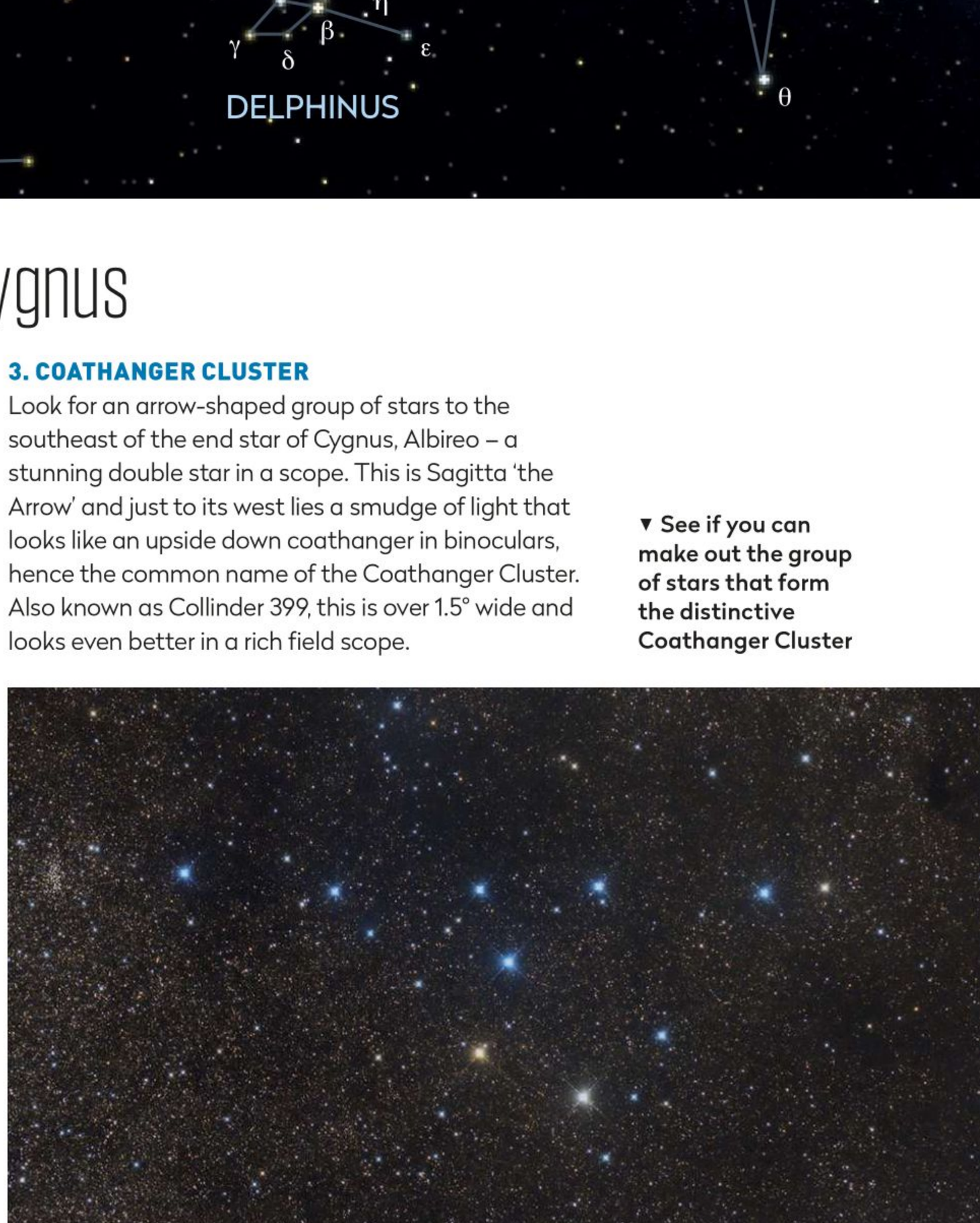
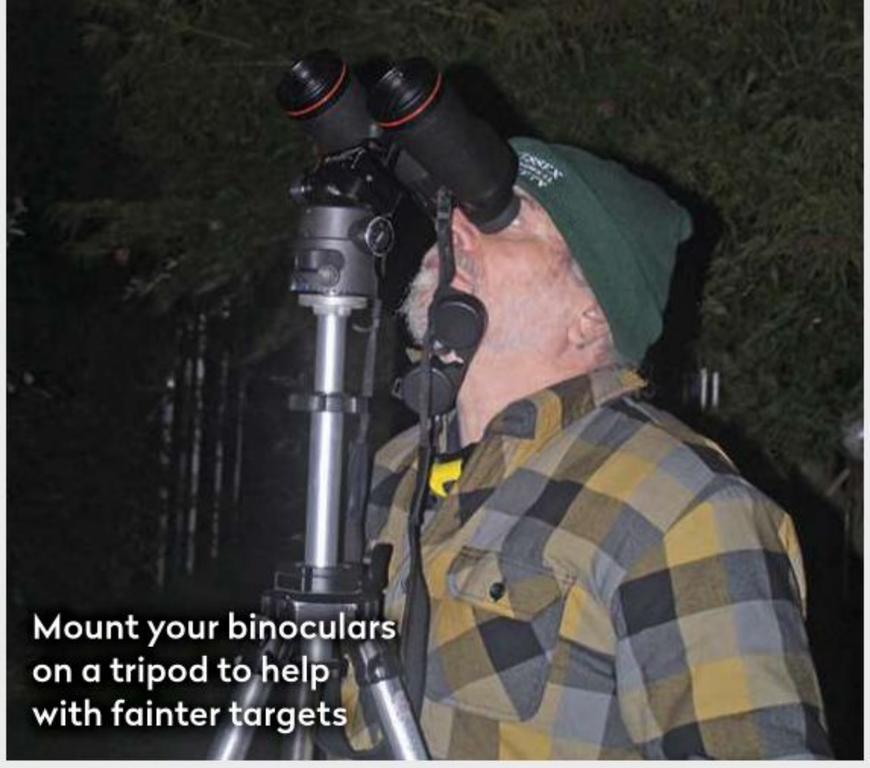


CHART BY PETE LAWRENCE, HANNES BACHLEITNER/CCDGUIDE.COM, FRANZ KLAUSER/MANFRED WASSHUBER/CCDGUIDE.COM, THOMAS HENNE/CCDGUIDE.COM, STEPHEN TONKIN


Mount your binoculars on a tripod to help with fainter targets

Getting the best view

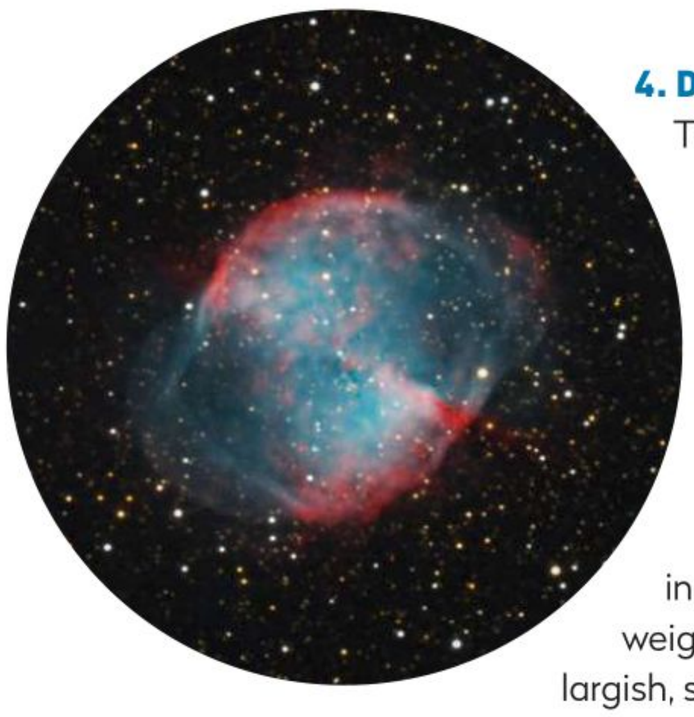
Apart from the naked eye, a good pair of 7x50 or 10x50 binoculars will really enhance your viewing and discovery of these targets. Put them on a tripod rather than holding them and the extra stability will help you pick out far fainter objects. Most beginners' telescopes will show our selected targets, but for casual viewing of the Milky Way's treasures an 8-inch Dobsonian telescope with 26mm and 10mm eyepieces (or a 26mm eyepiece and a 2x Barlow) will give lovely views. Don't expect what you see in the eyepiece to match the Hubble Space Telescope which can reveal far fainter colour.

6. DOUBLE DOUBLE (EPSILON LYRAE)

Northeast of Vega lies the star Epsilon (ε) Lyrae. Observing through binoculars or with the naked eye reveals that it is in fact two stars. Now turn a telescope on it, and at high magnification each star is double again, hence its common name the 'Double Double' – vivid proof that what we see with the naked eye is not always the full story.

7. VEIL NEBULA

Locate Gienah (Epsilon (ε) Cygni). Two fainter stars lie to its south, one being 52 Cygni. This target requires a telescope, for here is a large supernova remnant, parts of which can be spotted with care. The Western Veil lies close to 52 Cygni while the Eastern Veil forms a shallow triangle with Epsilon (ε) and Zeta (ζ) Cygni. This target benefits from viewing with a specialised OIII filter, especially if you suffer from light pollution. ▸

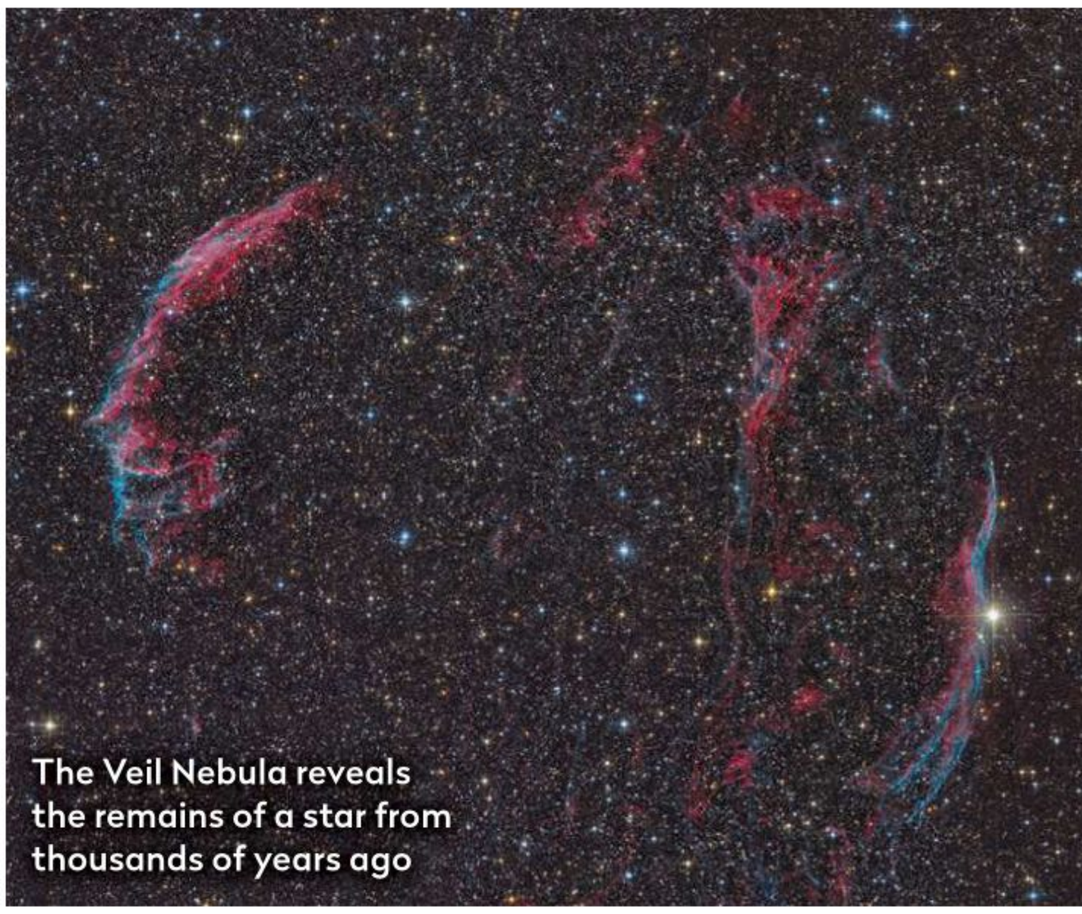

▲ The Dumbbell Nebula is a star shedding its outer layer

4. DUMBBELL NEBULA, M27

Turning to the 'point' end of Sagitta, from the end star Gamma (γ) Sagittae drift north using binoculars and look for a small roundish smudge of light with a star to its north. This is the stunning and quite bright planetary nebula, the Dumbbell Nebula, M27, so-called as it does indeed look like a pair of dumbbell weights. A small telescope reveals a largish, slightly misshapen patch of light; what you are looking at is an almost sideways-on view of a dying star throwing off its outer layers.

5. RING NEBULA, M57

Look at the south of Lyra for the stars Sheliak (Beta (β) Lyrae) and Sulafat (Gamma (γ) Lyrae). Roughly halfway between them, seek out a small patch of light with your scope. This is M57, the Ring Nebula. If you can aim a telescope at it and increase the magnification, then you may notice the hollow interior that gives it its name. With this planetary nebula we are looking vertically down its polar axis.


The Veil Nebula reveals the remains of a star from thousands of years ago

The north northeastern sky: Auriga to Cassiopeia

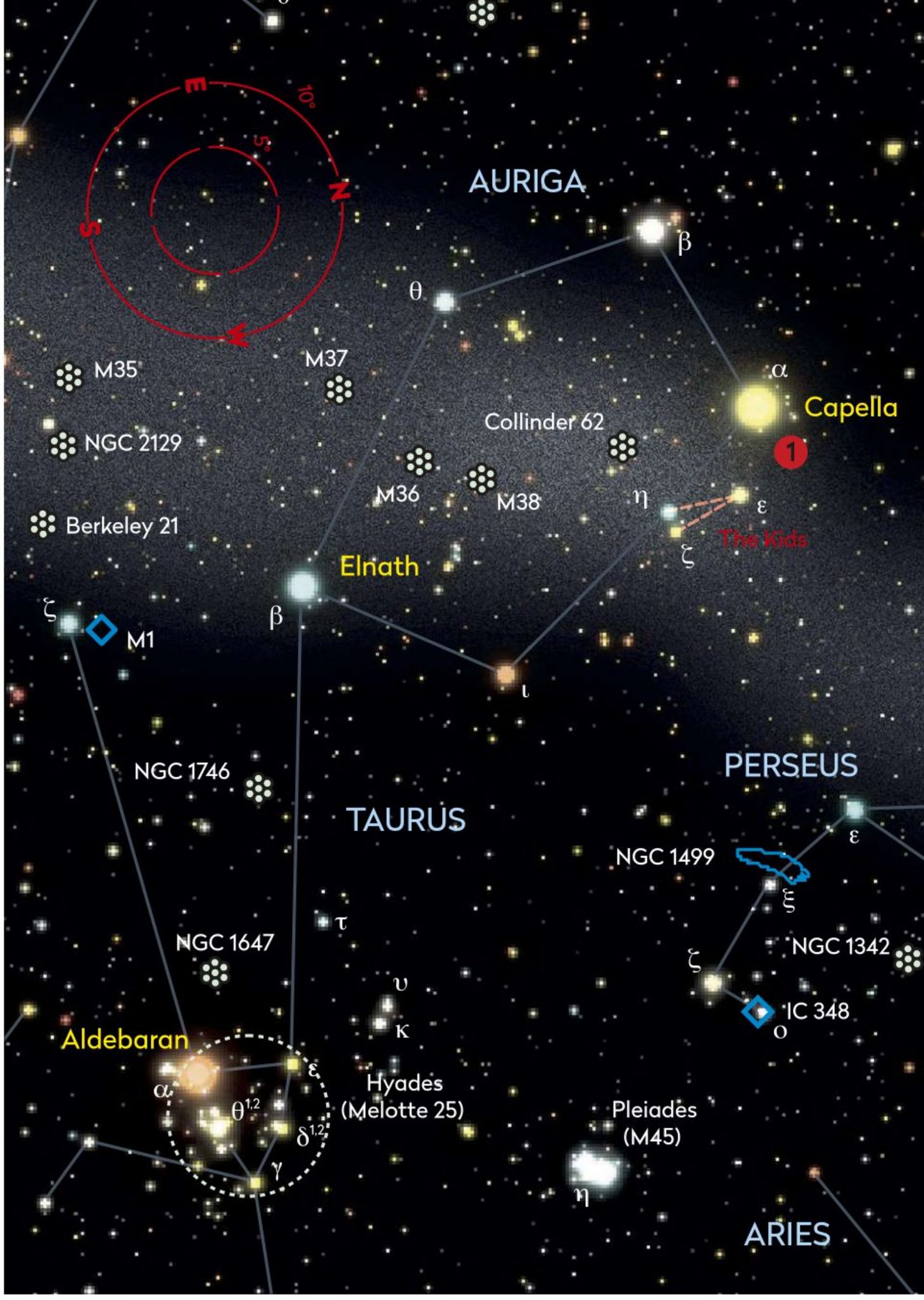


CHART BY PETE LAWRENCE, RWITTICH/ISTOCK/GETTY IMAGES, STGRAFIX/ISTOCK/GETTY IMAGES, FABIAN NEYER/CCDGUIDE.COM

1. CAPELLA AND THE KIDS

Low down towards the north northeastern horizon we find the bright star Capella, a yellow-tinted example lying just 43 lightyears away, with a similar spectral classification to our own Sun. Capella never sets for the UK so is circumpolar. To its southwest lies a lovely asterism, a triangle of stars called The Kids consisting of Epsilon (ε), Zeta (ζ) and Eta (η) Aurigae. In binoculars they make a great sight with the fainter part of the Milky Way behind them as a backdrop.

2. MIRFAK & OB3 STAR ASSOCIATION

The backbone of Perseus is dominated by the star Mirfak (Alpha (α) Persei), but look around it with a pair of binoculars and you'll realise there are many other examples here too. This is the Alpha Persei Cluster – aka the Perseus OB3 Association – and it's a great example of a star cluster best seen with a pair of binoculars. It lies around 560 lightyears away and while most of the members are B-type stars, Mirfak itself is a white-yellow supergiant of the spectral type F5 shining at mag. +2.

3. NGC 1545 AND 1528

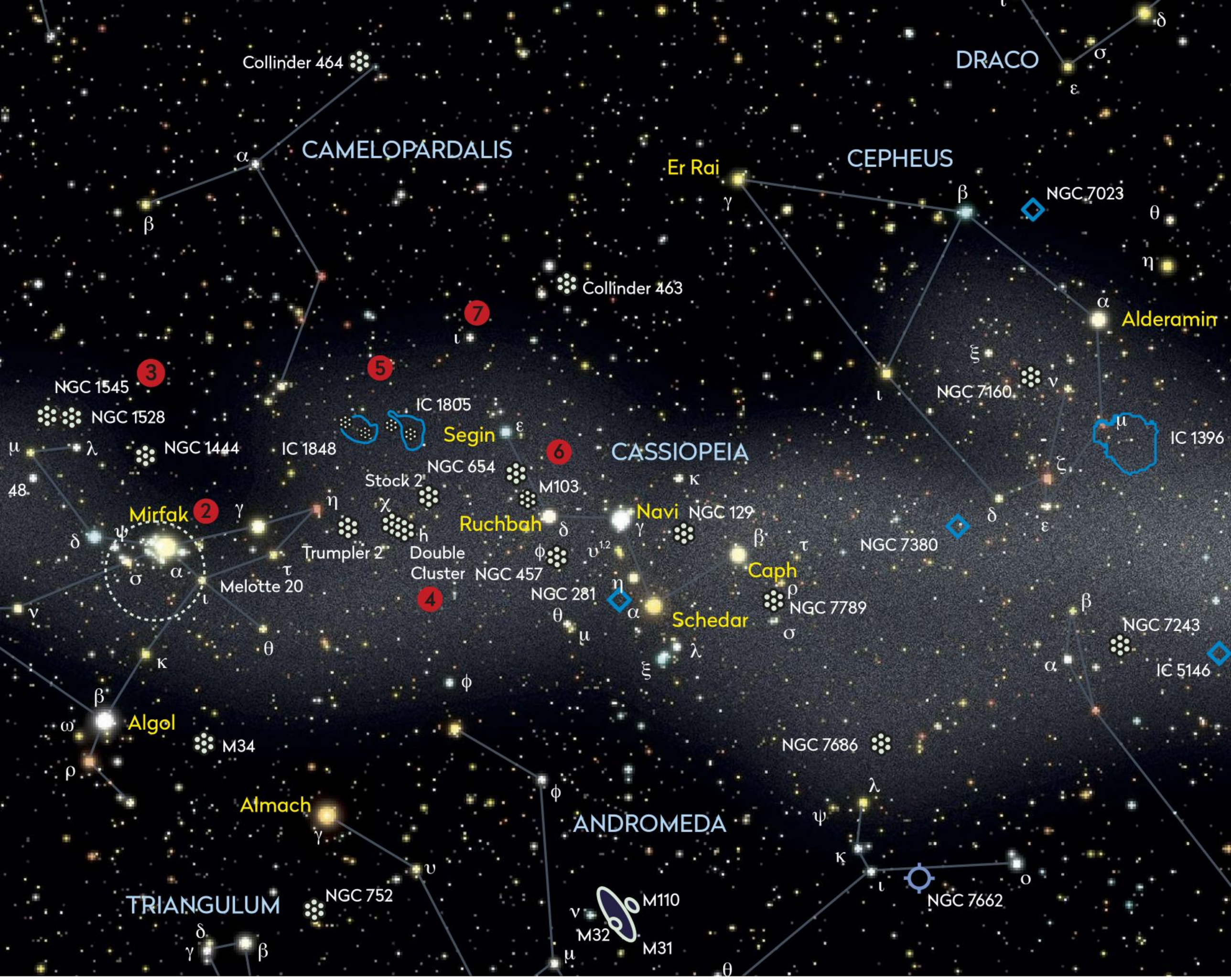
By following the line of stars downwards through the Alpha Persei Cluster to Delta (δ) Persei, we find a triangle of stars to its east formed by 48, Mu (μ) and Lambda (λ) Persei. To their east lie two star clusters at mag. +6.2 and +6.4, both seen well in binoculars and small telescopes. NGC 1545 and NGC 1528 are

◄ The Double Cluster, NGC 884 and NGC 869, is one of the wonders of the Milky Way

Astronomy writer and broadcaster **Paul Money** is reviews editor for *BBC Sky at Night Magazine*

How sky darkness affects Milky Way views

The stream of gentle light that is the Milky Way arching overhead at this time of year is a wonderful sight to behold, yet to fully appreciate it you need dark skies. As light pollution increases, so the view of that milky band diminishes, and it's sad to think there are many who can no longer appreciate its beauty from their gardens due to the blight of light pollution. From city centres little, if anything, will be seen so, ideally, a site in the countryside away from urban centres will enhance your view of this delicate river of light.



▲ If the conditions are dark enough, a telescopic view of the Heart and Soul Nebulae can give a wonderful imaging opportunity

often compared to the brighter and better-known Double Cluster (see below).

4. DOUBLE CLUSTER

Surely the best cluster double act in the Northern Hemisphere sky, NGC 884 and NGC 869, can be seen as a misty patch to the naked eye between Perseus and Cassiopeia. Look through binoculars and they are revealed as a pair of clusters. They are a gem to view and, just 100 lightyears apart, lie an estimated 7,500 lightyears away in the Perseus Arm of the Milky Way.

5. HEART AND SOUL NEBULAE

The Heart and Soul Nebulae are found to the eastern side of the Double Cluster and, like it, are members of the Milky Way's Perseus Arm. They need clear, dark skies, plus a telescope to view properly. An ideal target for wide-field astrophotography, their official designations are IC 1805 and IC 1848; their names come from their appearance in photographs.

6. 'W' OF CASSIOPEIA (AND THE M103 STAR CLUSTER)

In the northeast sky, look for a large 'W' shaped group of stars; this is the constellation of Cassiopeia, the Queen. The five primary stars that make up the 'W' are Caph, Schedar, Navi, Ruchbah and Segin. Use binoculars to look near Ruchbah in the direction of Segin and there is a small open cluster, M103. The brightest stars in it form a triangle, with more visible through a scope.

7. TRIPLE STAR IOTA CASSIOPEIAE

Using Ruchbah and Segin, extend a line almost the same distance past the latter until you come to mag. +4.6 Iota (ι) Cassiopeiae. This is another unsung gem, often overlooked for the 'W' asterism. A telescope view reveals it as a double star. If conditions allow, increase the magnification and a third closer companion becomes evident, showing it is a visual triplet.

BBC Sky at Night MAGAZINE

16-PAGE CENTRE PULLOUT

The Sky Guide

OCTOBER 2019

A TRICK OF THE MOONLIGHT

Discover the impressive optical effect known as Alexander's Beaded Rim

JUPITER AND THE MOON

Observe a close daylight conjunction

PETE LAWRENCE

DISTANT URANUS AND ITS BRIGHT MOONS

Spot the green hue of the seventh planet

About the writers

Astronomy expert **Pete Lawrence** is a skilled astro imager and a presenter on *The Sky at Night* monthly on BBC Four

Stephen Tonkin is a binocular observer. Find his tour of the best sights for both eyes on page 54

Also on view this month...

- Mercury and Venus in the evening sky
- Go on the trail of Einstein's Cross
- A double shadow transit by Jupiter's moons

Red light friendly

To preserve your night vision, this Sky Guide can be read using a red light under dark skies

Get the Sky Guide weekly

For weekly updates on what to look out for in the night sky and more, sign up to our newsletter at **www.skyatnightmagazine.com**

OCTOBER HIGHLIGHTS

Your guide to the night sky this month

◀ Tuesday 1

A dark, moonless start to October presents a good opportunity to look at the Andromeda Galaxy, M31, and Triangulum Galaxy, M33, both of which are high in the sky in the early hours.

Saturday ▶ 5

Mag. +0.9 Saturn and the first quarter Moon appear just 1° apart at around 22:30 BST (21:30 UT).

At 20:00 BST (19:00 UT) a tenth-magnitude star lies 34 arcseconds from the centre of Jupiter.

Wednesday 9

The early morning sees the peak of the annual Draconid meteor shower. The ZHR is as high as around 20 meteors per hour. On 10 October, a bright waxing gibbous Moon sets around 03:00 BST (02:00 UT).

Thursday 10

With a maximum ZHR of five meteors per hours, the Southern Taurids reaches its peak. The Northern Taurids peak later in the year.

Sunday 13

The minor planet 29 Amphitrite reaches opposition today, appearing at mag. +8.7 in Pisces. Turn to page 47 for further information.

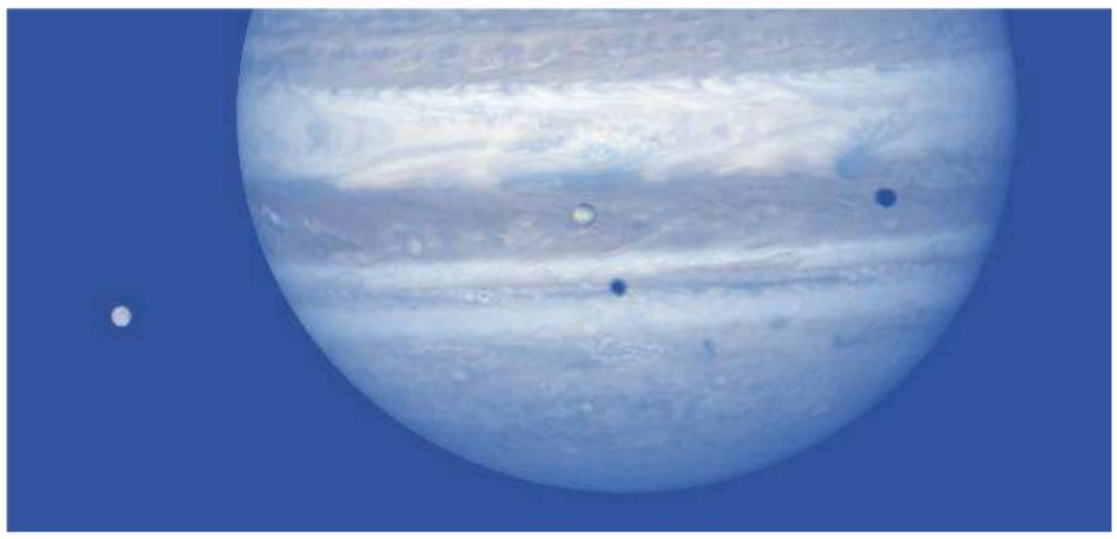
Sunday 20

Mercury is at its greatest eastern elongation of 24.6°. Despite this, the planet isn't well located as seen from the UK.

The Epsilon Geminid meteor shower is at its peak, with a ZHR of 3 meteors per hour.

Thursday ▶ 24

A double shadow transit takes place on Jupiter's disc today – the twist being that it occurs during the hours of daylight. Turn to page 47 for details on how to observe it.



Friday 25

The minor planet 9 Metis reaches opposition today. Metis will appear at a favourable mag. +8.6 in the constellation of Cetus.

Monday 28

Today, Uranus reaches opposition in the constellation of Aries. Turn to page 48 for details on how to locate it, and page 76 for details on how to image its moons.

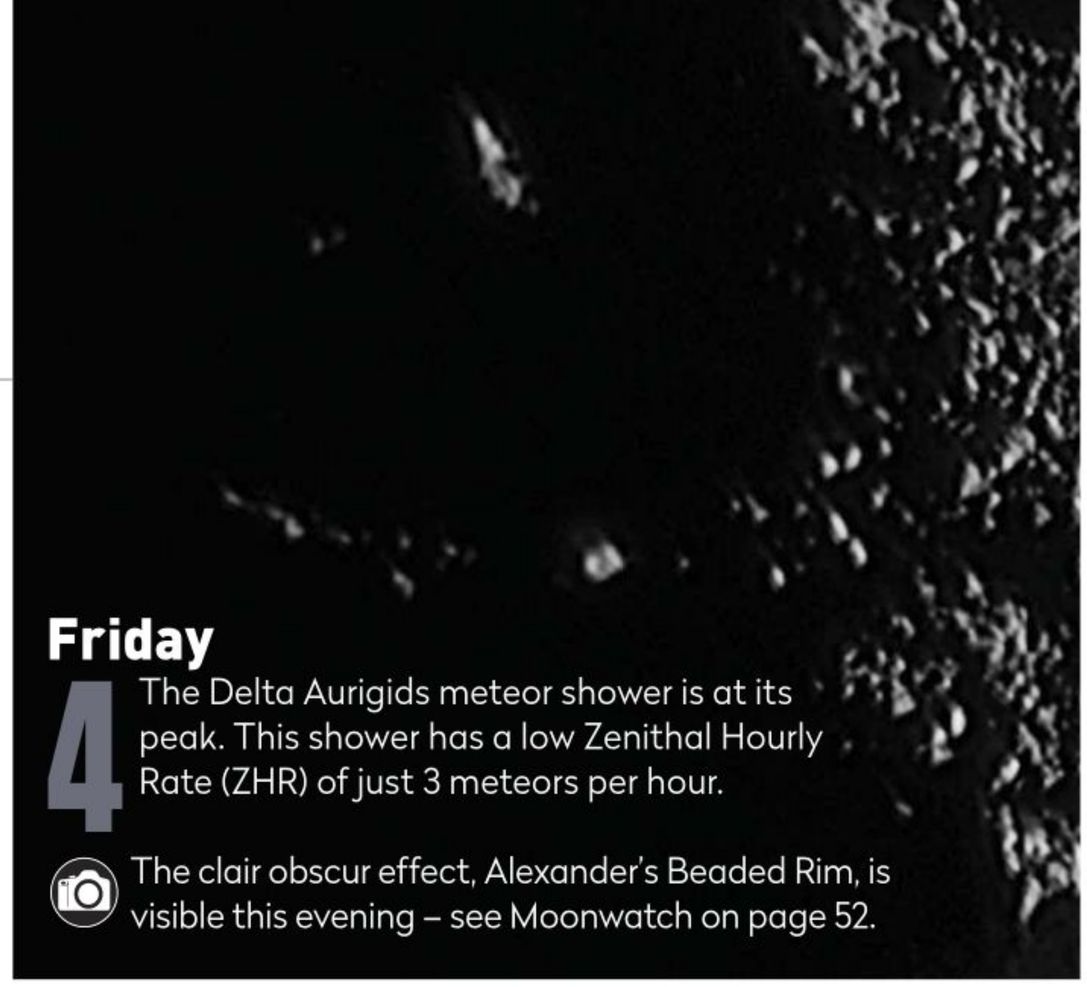
Tuesday ▶ 29

If you have clear skies, look for Venus shortly after sunset low in the southwest. This evening, mag. –3.8 Venus appears 2.8° below a 3%-lit waxing crescent Moon. Turn to page 46 for more information.

Wednesday 30

If you can catch bright Venus shortly after sunset, you might be able to catch a glimpse of mag. +0.5 Mercury 2.6° to the south of it. The window of opportunity is short though.

PETE LAWRENCE X 7



Friday

4 The Delta Aurigids meteor shower is at its peak. This shower has a low Zenithal Hourly Rate (ZHR) of just 3 meteors per hour.

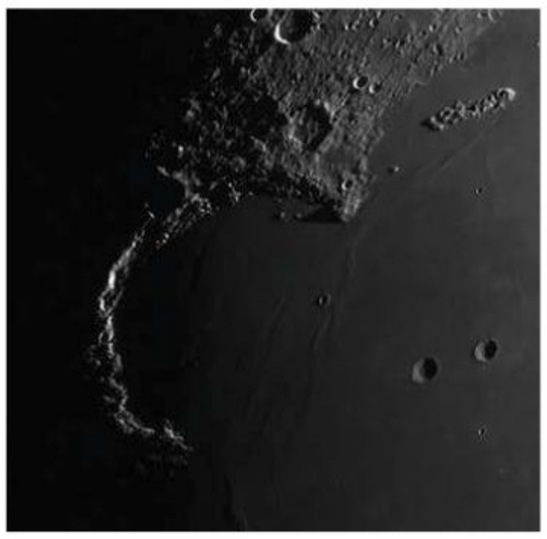
The clair obscur effect, Alexander's Beaded Rim, is visible this evening – see Moonwatch on page 52.

Thursday

3 A 30%-lit waxing crescent Moon appears 1.5° to the northwest of mag. –1.9 Jupiter this evening.

Tuesday ▶

8 The clair obscur effect known as the Jewelled Handle is visible as sunlight catches the mountain peaks of Montes Jura, which borders Sinus Iridum (the Bay of Rainbows).



◀ Monday

21 Today is the peak of the Orionid meteor shower, which has a maximum ZHR of 20 meteors per hour. But a 55%-lit waning gibbous Moon will be located not too far from the radiant, reducing the number of meteors that can be seen.

Sunday

27 With the Moon out of the way, the sky is dark for exploring Camelopardalis. See our Deep-Sky Tour on page 56.

The clocks go back by one hour, bringing daylight savings time to an end for the UK.

Thursday

31 Jupiter will appear 24 arcminutes south of the centre of a 14%-lit Moon during daylight – that's 9 arcminutes from the Moon's southern limb. Turn to page 46 for details on how to locate it.

Family stargazing

Conjunctions – two objects appearing close to one another – can be a great way to point out different objects and explain how they move relative to one another. There are several easy to spot conjunctions this month: the Moon near Jupiter on 3 October, near Saturn on 5 October, and Venus towards the end of the month. The two earlier events can be used to introduce conjunctions, and so build excitement for hunting Venus in twilight. Be careful with this event – make sure it is stressed that no one should look at the Sun. Looking for Venus is only safe after the Sun has set.

NEED TO KNOW

The terms and symbols used in The Sky Guide

Universal time (UT) and British Summer Time (BST)
Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT

RA (Right ascension) and dec. (declination)
These coordinates are the night sky's equivalent of longitude and latitude, describing where an object is on the celestial 'globe'

Family friendly
Objects marked with this icon are perfect for showing to children

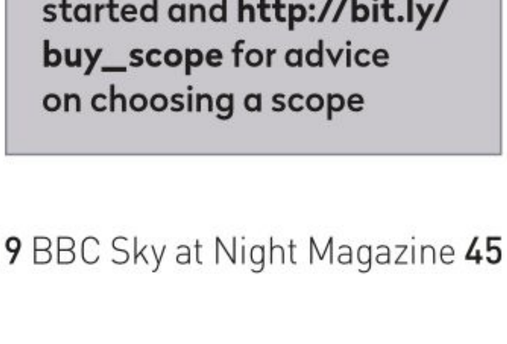
Naked eye
Allow 20 minutes for your eyes to become dark-adapted

Photo opp
Use a CCD, planetary camera or standard DSLR

Binoculars
10x50 recommended

Small/ medium scope
Reflector/SCT under 6 inches, refractor under 4 inches

Large scope
Reflector/SCT over 6 inches, refractor over 4 inches



GETTING STARTED IN ASTRONOMY

If you're new to astronomy, you'll find two essential reads on our website. Visit **http://bit.ly/10_easylessons** for our 10-step guide to getting started and **http://bit.ly/buy_scope** for advice on choosing a scope

DON'T MISS

A month for CONJUNCTIONS

BEST TIME TO SEE: The evenings of 3 and 5 October; just after sunset on 29 and 30 October; and at 14:10 UT on 31 October

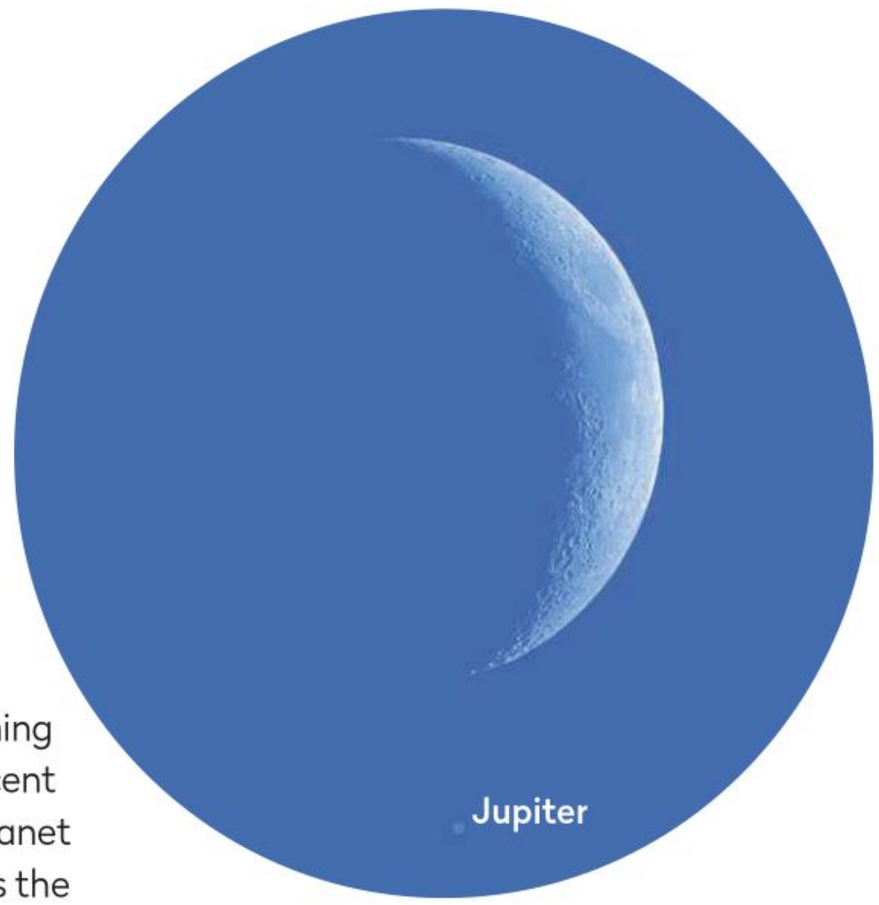
The term conjunction has several meanings in astronomy, but in a general sense it is taken to mean a close proximity between two or more objects in the sky. If the Moon appears near Venus, they are loosely described as being in conjunction. The majority of conjunctions do concern the Moon. Another type are solar conjunctions, which occur when the main planets line up with the Sun. Alignment on the opposite side of the Sun to Earth is known as a superior conjunction. Mercury and Venus can also line up with the Sun on the same side as Earth. This is an inferior conjunction.

A more formal definition of conjunction is when two objects share the same ecliptic longitude. The Ecliptic is a great circle described by the apparent annual motion of the Sun. Alternatively, a conjunction in right ascension occurs when two objects share the same right ascension value.

This month, there are several conjunctions occurring. On the evening of 3 October, a 30%-lit waxing crescent Moon appears close to the bright planet Jupiter. As the pair descend towards the western horizon, their separation, centre-to-centre, reduces to around 1.3°. On 5 October, it's the turn of Saturn to get a visit from the Moon, when the pair will be separated by an even tighter 1° at around 22:30 BST (21:30 UT). Earlier on the same evening, a telescopic view of Jupiter will reveal a tenth-magnitude star 34 arcseconds from the planet's centre.

Things then quieten down for a few days. There's an interesting daylight Jovian double shadow transit (see opposite) on 24 October. Transits and eclipses can also be considered a form of precisely aligned conjunction.

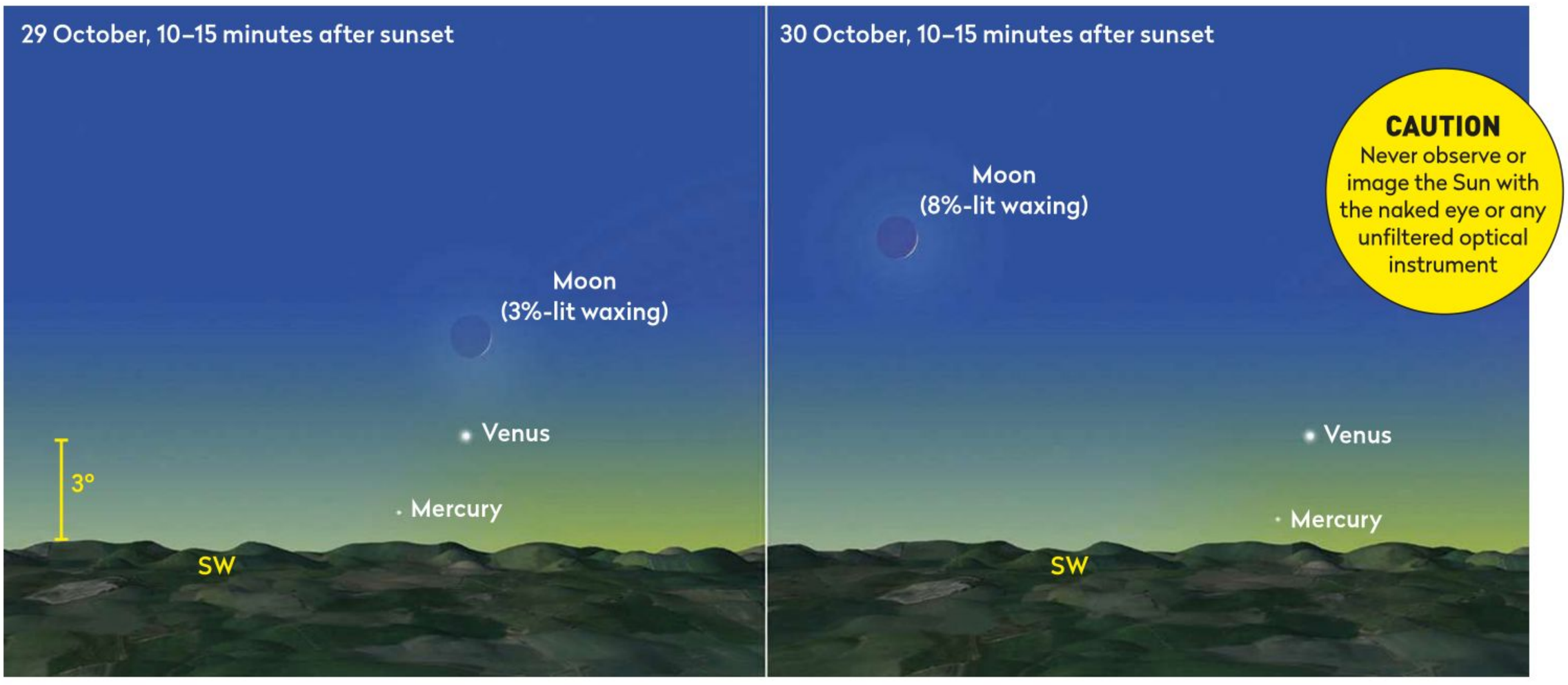
Then just after sunset on 29 October, mag. –3.8 Venus appears 3° below a slender 3%-lit waxing crescent Moon. Despite being twilight challenged, Venus



▲ **A 'ghostly' Jupiter will appear just below the Moon on 31 October at 14:10 UT**

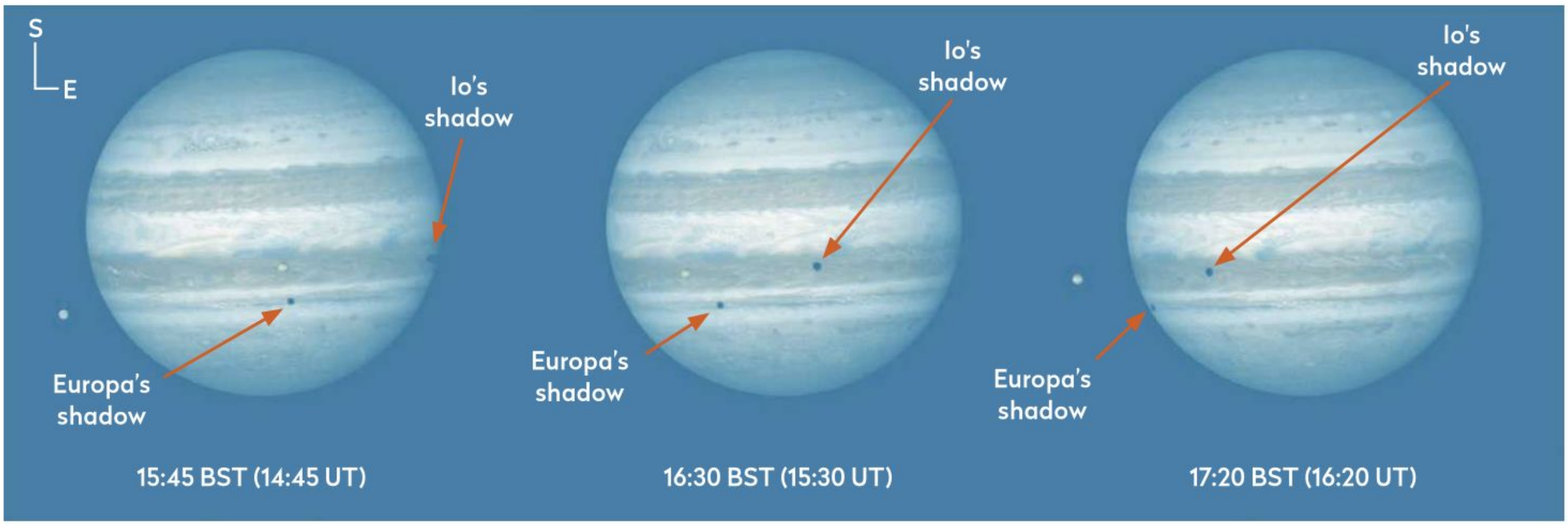
should stand out against the bright post-sunset sky given a flat horizon. The following evening, look for Venus with binoculars – after making sure the Sun has truly set. If the sky is clear, you should be able to see mag. +0.5 Mercury, 2.6° below Venus, or approximately half the field-of-view diameter for the average pair of binoculars.

Finally, on 31 October, if you can find the 14%-lit waxing crescent Moon at 14:10 UT in a daylight sky, use binoculars or a low magnification telescope and see if you can spot a ghostly low contrast Jupiter 24 arcminutes south of the Moon's centre and 9 arcminutes from its southern limb.



ALL PICTURES: PETE LAWRENCE

▲ **Look towards the horizon just after sunset on 29 and 30 October to catch a view of Venus and Mercury**



▲ Look at Jupiter on 24 October, from 15:43 BST, to track the shadows of its moons Io and Europa (shown here as a south-up telescopic view)

A daylight double shadow transit

BEST TIME TO SEE: 24 October, 15:43–17:22 BST (14:43–16:22 UT)

On 24 October the Galilean moons Io and Europa cast their shadows onto Jupiter's atmosphere at the same time. The shadows are on the disc together between 15:43 BST (14:43 UT) and 17:22 BST (16:22 UT), during daylight conditions.

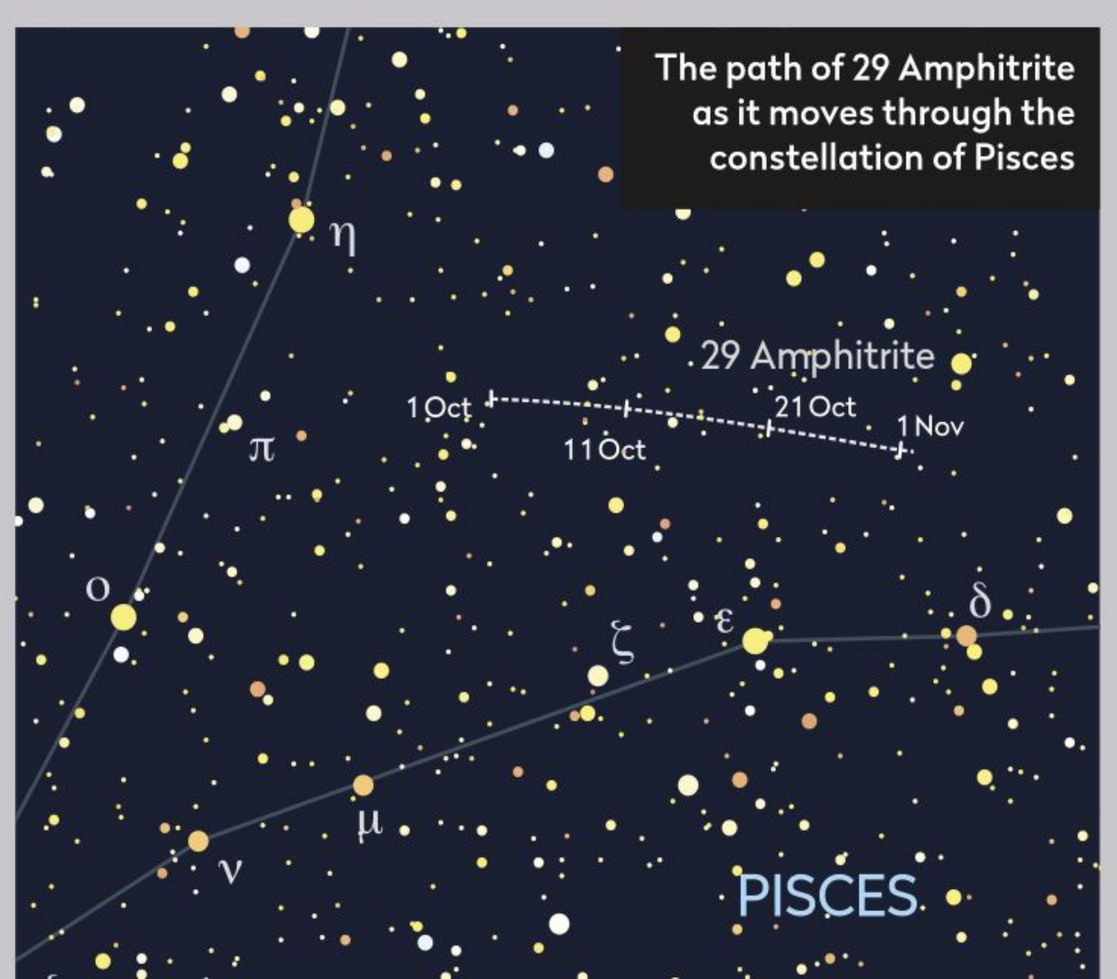
Although Venus can be spotted against a bright blue sky with unaided eyes, Jupiter and Saturn require help. Mars could also be a potential daylight object, but for this to happen it needs to be at its brightest. This occurs around opposition, which places the planet firmly in a dark night-time sky. The biggest hurdle with daylight viewing is finding your target. This can be achieved with a Go-To system as long as it can be operated during the day. Obtaining a reference position using the Sun works well, but you need to make sure no unprotected optical apertures are pointing at the Sun when you do so. This includes the main scope and the finder. If you're not sure what you are doing, don't attempt it.

Offsetting from the Sun using setting circles is another way to locate a planet. If you are struggling, it's worth noting that Jupiter will be due south at 16:26 BST (15:26 UT). From latitude 53° north, this places it at an altitude of 14°.

Jupiter by day is not like Jupiter by night. Although bright at mag. –1.8, it appears with extremely low contrast against a bright blue daylight sky. The moon shadows should fare quite well but aren't the largest cast by the Galilean four – Ganymede's and Callisto's are much larger. The best way to observe the transit is to use a scope with an infrared-sensitive camera fitted. Using an infrared pass filter will then provide higher contrast, causing the blue of the surrounding sky to appear very dark.

Asteroid 29 Amphitrite reaches opposition

BEST TIME TO SEE: All month, opposition on 13 October



A double opportunity to see two large asteroids reach opposition occurs this month. Find out about asteroid 9 Metis on page 53. Meanwhile, asteroid 29 Amphitrite reaches opposition, and peak brightness, mid-month on 13 October in the constellation of Pisces. On 1 October it appears to shine at mag. +9.0 brightening to +8.7 by the 13th, fading back to mag. +9.1 by 31 October. Its maximum peak magnitude is +8.6, so this is a good opposition with the asteroid a reasonable target for binoculars or a small scope.

Amphitrite's path keeps it within the faint wedge-shaped outline of Pisces at a decent UK altitude, not too far from Epsilon (ε) and Delta (δ) Piscium. As ever with asteroids, the best way to observe Amphitrite is to sketch or image the field where you think it's located. Do this over several nights and as long as you've been looking at the correct area of sky, Amphitrite should make itself known by virtue of its movement against the background stars.

Amphitrite is a stony, siliceous or S-type asteroid, one of the largest of this type, with a diameter of around 200km. It was discovered in 1854 at the South Villa Observatory in London's Regent's Park.

PICK OF THE MONTH

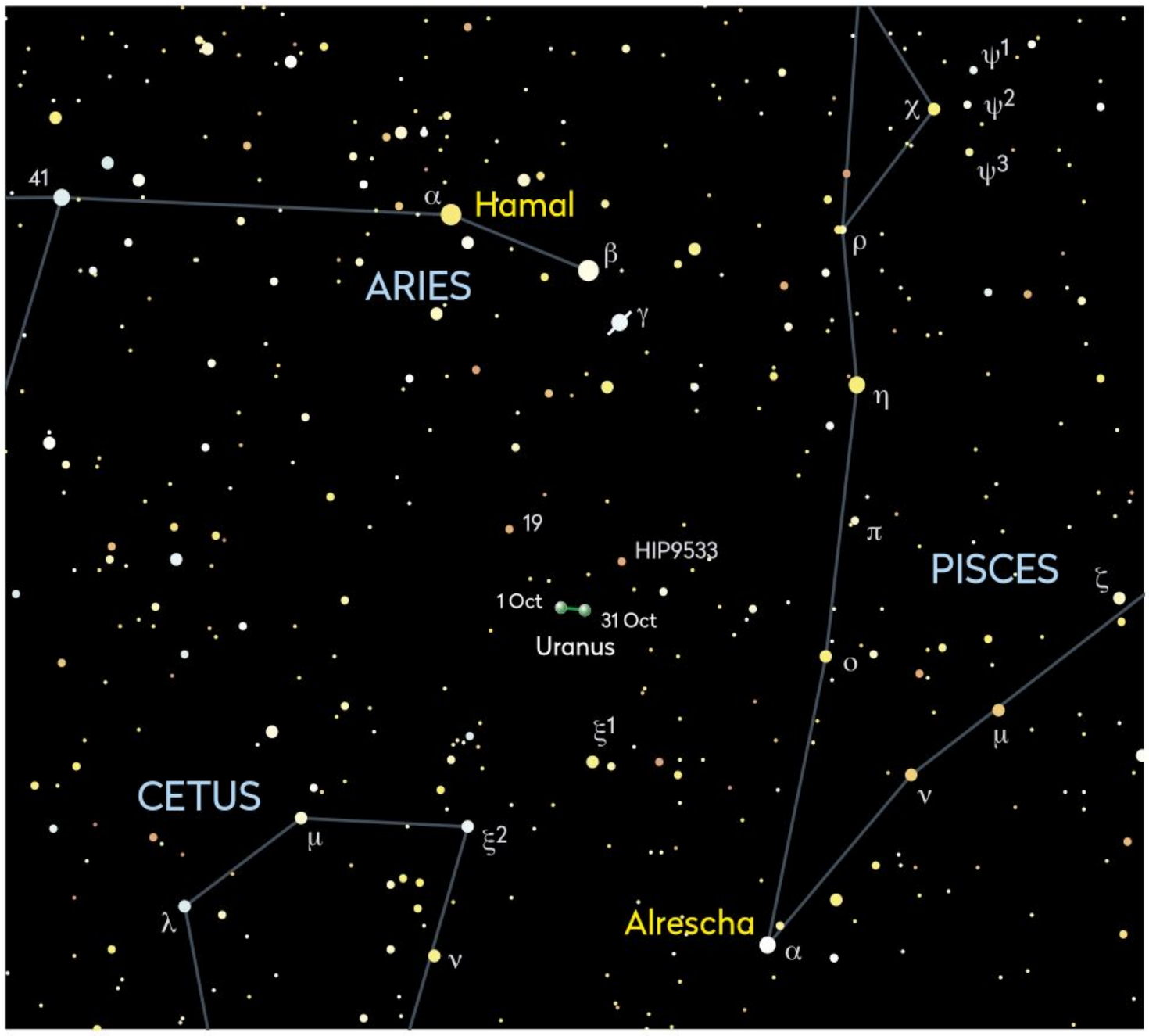
Uranus

Best time to see:
28 October, 00:00 UT
Altitude: 49.5°
Location: Aries
Direction: South
Features: Small disc, green colour, faint belts, moons

Uranus reaches opposition on 28 October. It's currently located within Aries roughly 9° to the north of Alrescha (Alpha (α) Piscium). It may seem odd to reference the planet's position relative to a star outside of Aries which is a reasonable distance away, but this is part of the current issue with Uranus. Although it's the best placed planet for the UK at present, it's in a fairly barren part of the sky with few bright or middle-bright stars nearby to guide you to it.

The brightest star in Aries is Hamal (Alpha (α) Arietis) and this lies 11° to the north of the planet. One rough and ready way to locate Uranus is therefore to use a wide-field instrument such as binoculars and point it at the location roughly midway between Alrescha and Hamal.

At mag. +5.7 Uranus is on the threshold of naked eye visibility but is best seen with binoculars. The field around the planet only has a smattering of stars of similar brightness. One way to identify Uranus is to look out for the isosceles triangle formed with mag. +5.7 19 Arietis and mag. +6.0 HIP9533. Uranus marks the southern vertex of this triangle. Throughout the course of the month, the planet slowly moves towards the west but only traverses an angular distance of 1.1°. Consequently, this description holds for all of the month.



▲ Use Hamal, the brightest star in Aries, as a locator for Uranus. The star lies 11° north

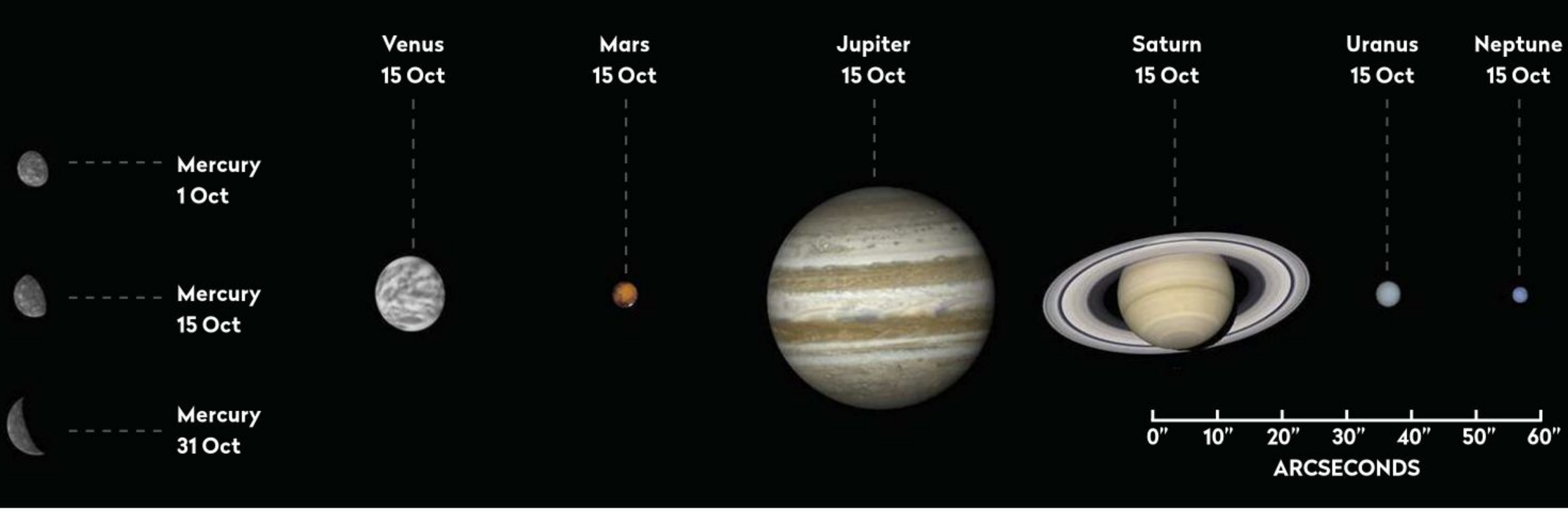
Reaching a peak altitude of around 50° when due south, Uranus is suited for telescope viewing. Its disc appears small at just under 4 arcseconds across, so don't expect any detail unless you own a large scope. However, what does stand out is the planet's green hue. Another highlight is catching a glimpse of its brightest moons.

▸ *Turn to page 76 for advice on how to image the moons of Uranus*

PETE LAWRENCE X 3

The planets in October

The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to show its orientation through a telescope



Mercury

Best time to see: 31 October, 10–15 minutes after sunset
Altitude: Less than 1° (very low)
Location: Libra
Direction: Southwest

Mercury is poorly positioned at the start of October. Currently an evening object, the shallow angle the ecliptic makes with the western horizon at sunset keeps its altitude too low for observation. A greatest eastern elongation of 24.6° occurs on 20 October but again, Mercury is poorly placed for this.

Venus

Best time to see: 31 October, 20 minutes after sunset
Altitude: 2.5° (low)
Location: Libra
Direction: Southwest

Venus is increasing its apparent separation from the Sun in the evening sky. A shallow ecliptic angle means the planet hugs the horizon after sunset making it harder to see. A waxing crescent Moon appears 2.9° above Venus on 29 October and 14° to the east of the planet on 30 October. Venus is on the far side of its orbit relative to Earth and appears with a 93%-lit gibbous phase on 31 October, 10 arcseconds in diameter.

Mars

Best time to see: 31 October, 05:45 UT
Altitude: 5° (low)
Location: Virgo
Direction: East-southeast

Mars is a morning object slowly separating from the Sun. It's distant from Earth so appears tiny in a scope at 3 arcseconds across. At the month's end Mars rises two hours before the Sun.

Jupiter

Best time to see: 1 October, 19:30 BST (18:30 UT)
Altitude: 11°
Location: Ophiuchus
Direction: South-southwest

The observing window for Jupiter is closing. A 30%-lit waxing crescent Moon sits 1.5° northwest of the planet on 3 October, repeating its visit on 31 October. On this second occasion it appears as a 15%-lit waxing crescent, 1.8° from Jupiter around 18:30 UT. During daylight hours at 14:10 UT, Jupiter lies 24 arcminutes south of the lunar crescent's centre (see page 46).

Saturn

Best time to see: 1 October, 20:00 BST (19:00 UT)
Altitude: 14°
Location: Sagittarius
Direction: Just west of south

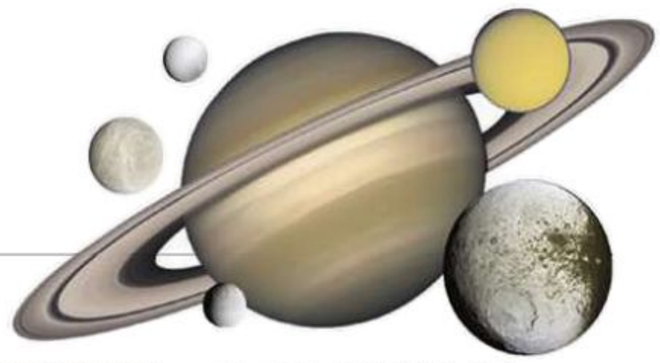
The lengthening nights help Saturn by extending the period when it's visible close to its highest point in the sky, due south. Saturn appears around mag. +0.9, northeast of the Teapot asterism in Sagittarius. Through a scope its rings are presented with the northern pole tilted towards Earth by 25°. On 5 October, look for the first quarter Moon below the planet at a separation of around 1° at 22:30 BST (21:30 UT), as measured from the centre of the Moon's disc. They will be low in the southwest.

Neptune

Best time to see: 1 October, 23:45 BST (22:45 UT)
Altitude: 31°
Location: Aquarius
Direction: South

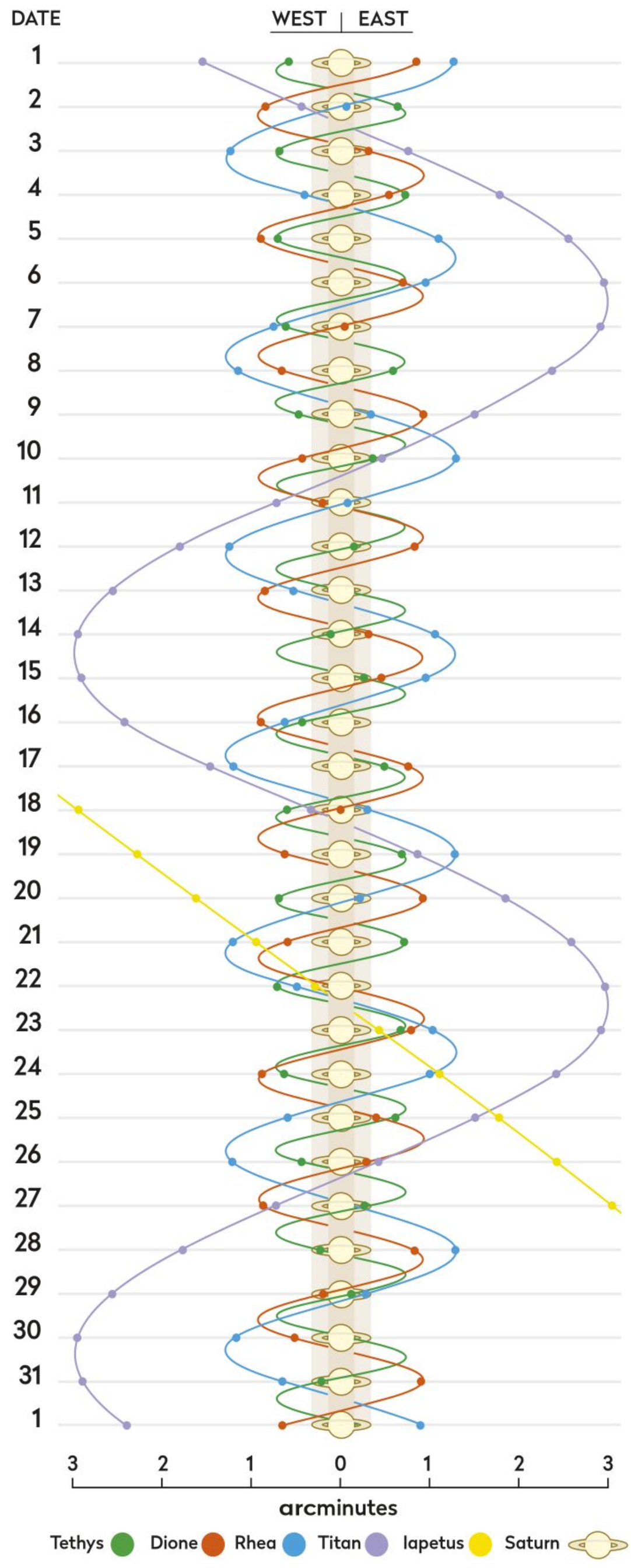
Neptune is close to mag. +4.2 Phi (ϕ) Aquarii. It was at opposition last month and is well placed for viewing. Neptune is the only main planet that can't be seen without optical assistance so you'll need binoculars to spot its mag. +7.8 dot.

More **ONLINE**
Print out observing forms for recording planetary events



SATURN'S MOONS: OCTOBER

Using a small scope you can spot Saturn's biggest moons. Their positions change dramatically during the month, as shown on the diagram. The line by each date represents 01:00 BST (00:00 UT).



THE NIGHT SKY – OCTOBER

Explore the celestial sphere with our Northern Hemisphere all-sky chart

KEY TO STAR CHARTS

Arcturus — STAR NAME

PERSEUS — CONSTELLATION NAME

GALAXY

OPEN CLUSTER

GLOBULAR CLUSTER

PLANETARY NEBULA

DIFFUSE NEBULOSITY

DOUBLE STAR

VARIABLE STAR

THE MOON, SHOWING PHASE

COMET TRACK

ASTEROID TRACK

STAR-HOPPING PATH

METEOR RADIANT

Circlet — ASTERISM

PLANET

QUASAR

STAR BRIGHTNESS:

MAG. 0 & BRIGHTER

MAG. +1

MAG. +2

MAG. +3

MAG. +4 & FAINTER

5° N E W S — COMPASS AND FIELD OF VIEW

MILKY WAY

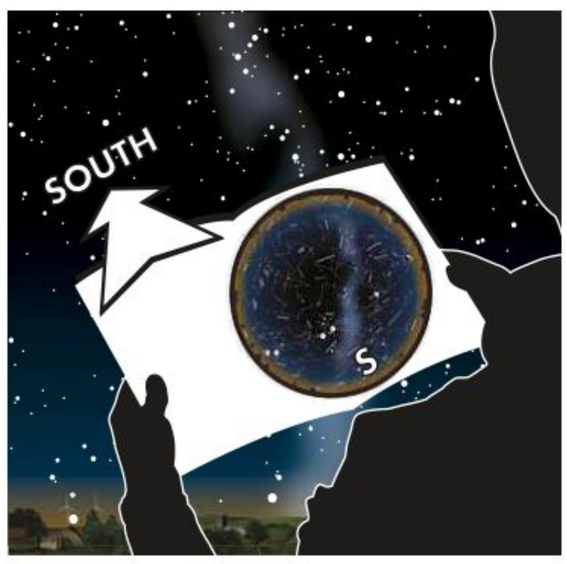
When to use this chart

1 October at 01:00 BST
15 October at 00:00 BST
31 October at 22:00 UT

On other dates, stars will be in slightly different positions because of Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

How to use this chart

1. Hold the chart so the direction you're facing is at the bottom.
2. The lower half of the chart shows the sky ahead of you.
3. The centre of the chart is the point directly over your head.



Sunrise/sunset in October*

Date	Sunrise	Sunset
1 Oct 2019	07:11 BST	18:48 BST
11 Oct 2019	07:29 BST	18:24 BST
21 Oct 2019	07:47 BST	18:01 BST
31 Oct 2019	07:06 UT	16:40 UT

Moonrise in October*

Moonrise times

1 Oct 2019, 10:33 BST	17 Oct 2019, 20:06 BST
5 Oct 2019, 15:21 BST	21 Oct 2019, 23:29 BST
9 Oct 2019, 17:37 BST	26 Oct 2019, 05:05 BST
13 Oct 2019, 18:44 BST	29 Oct 2019, 08:26 UT

*Times correct for the centre of the UK

Lunar phases in October

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
	1	2	3	4	5	6
7	8	9	10	11	12	13 FULL MOON
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28 NEW MOON	29	30	31			

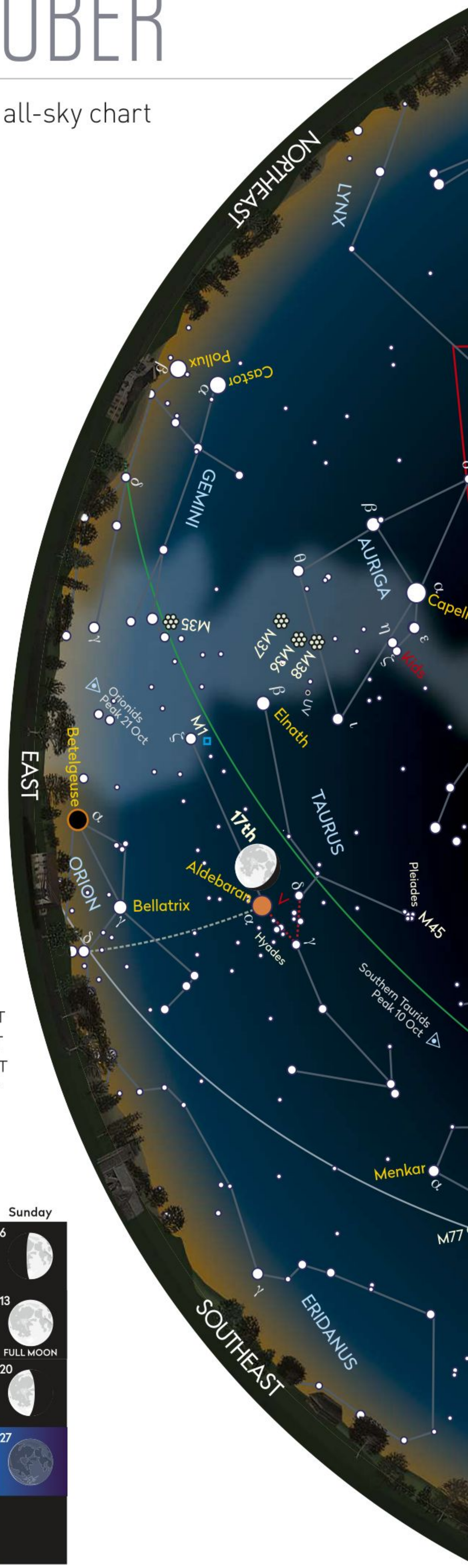


CHART: PETE LAWRENCE

NORTH
NORTHWEST
WEST
SOUTHWEST
SOUTH
URSA MAJOR
Mizar
Alcor
M51
M101
Merak
Dubhe
Phough
Thuban
M82
M81
Kochab
URSA MINOR
Polaris
Deep-sky tour, p56
CAMELOPARDALIS
RZ
SU
Double Cluster (Sword Handle)
House
CEPHEUS
Alderamin
DRACO
Draconids Peak 8 October
M13
Keystone
M92
HERCULES
CASSIOPEIA
M103
M52
Mirphak
Schedar
M76
M39
Deneb
Vega
LYRA
M57
AF
RR Lyr
M56
M29
Northern Cross
Albireo
CYGNUS
VULPECULA
M27
Summer Triangle
M71
SAGITTA
AQUILA
Altair
PERSEUS
Algol
M34
ANDROMEDA
M110
M31
M32
NGC 752
TRIANGULUM
M33
Alpheratz
Scheat
PEGASUS
Great Square of Pegasus
DELPHINUS
ARIES
Hamal
Ecliptic
Uranus
PISCES
M74
14th
Circlet
Steering Wheel
M2
AQUARIUS
CAPRICORNUS
Mira
Celestial Equator
Neptune
11th
8th
M15
EQUULEUS
M30
CETUS
NGC 246
Deneb Kaitos
NGC 247
PISCIS AUSTRINUS
Fomalhaut
SCULPTOR

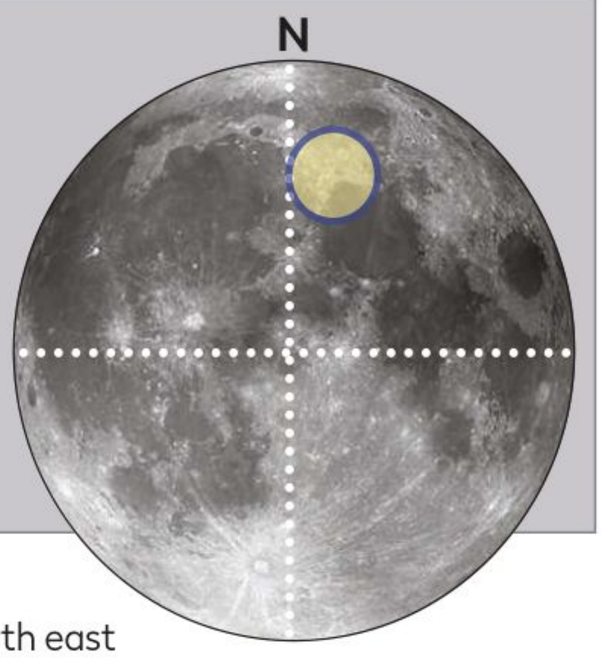
More ONLINE
Paul and Pete's Virtual Planetarium

MOONWATCH

October's top lunar feature to observe

Alexander

Type: Crater
Size: 83km
Longitude/latitude: 13.7° E, 40.3° N
Age: Older than 3.9 billion years
Best time to see: Six days after new Moon (4–5 October) and five days after full Moon (19–20 October)
Minimum equipment: 50mm refractor



Alexander is an eroded crater located north east of **Montes Caucasus**, just north of Mare Serenitatis. Its battered appearance can make it hard to identify. Its western half is defined by a broken rim with variable height lumps and bumps. These, for all intents and purposes, look very like the neighbouring mountain peaks which form the adjacent Caucasus range.

The western half of Alexander's floor is relatively flat, filled with darker lava than its immediate surrounds. However, as it passes to the east, it fritters away in a spatter of hills and rough terrain which forms the northern shore of **Mare Serenitatis**. There is no real evidence of the eastern rim at all, the crater floor appearing open to the east.

Only a few tiny satellite craters can be seen. **Alexander A** is just 4km across and requires a 200mm or larger scope to see. **Alexander B** is also 4km in diameter, located just south of A. **Alexander C** is marginally larger at 5km, situated just south of Alexander's rough southern edge.

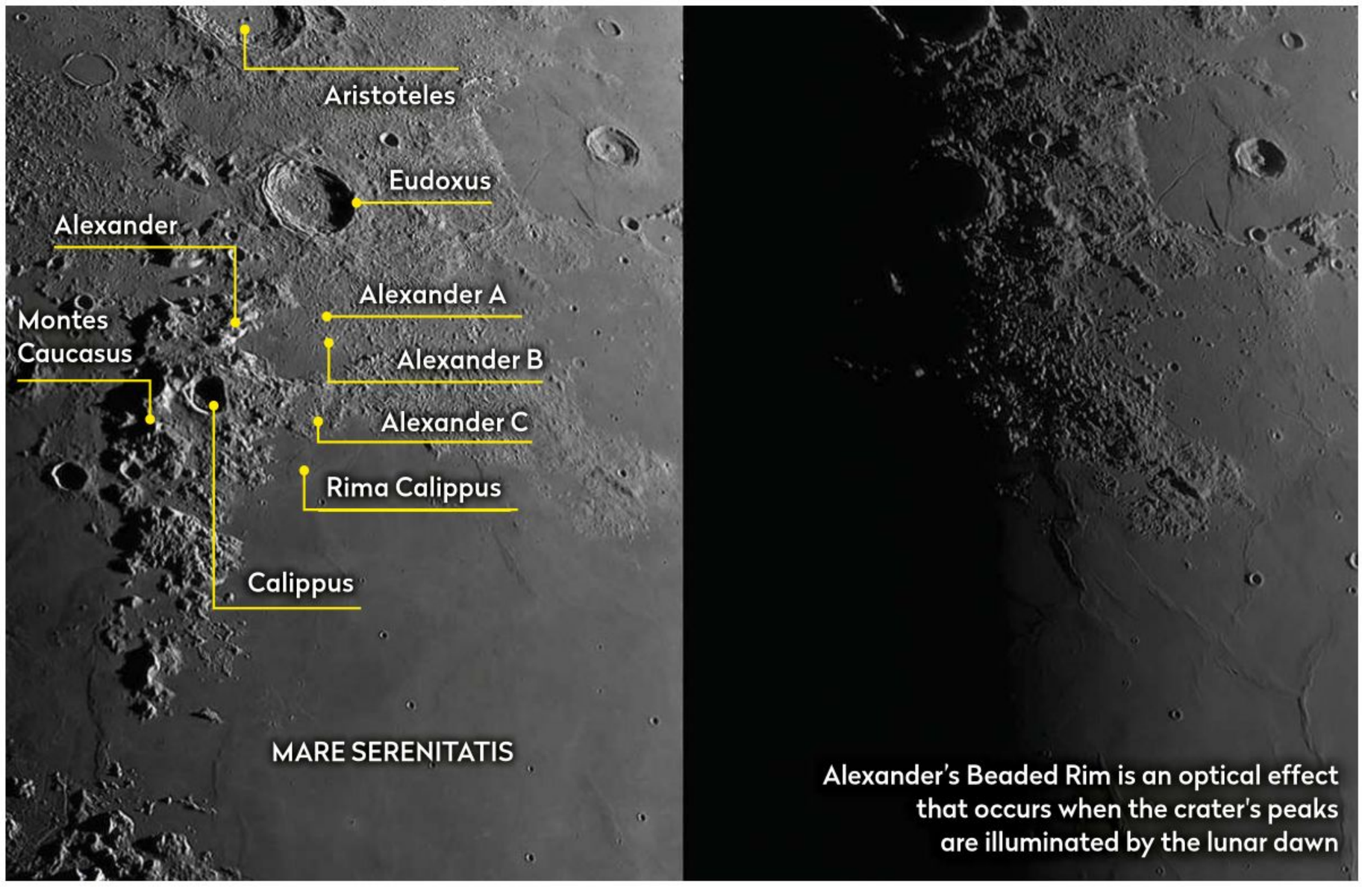
Although Alexander's eroded appearance can make direct identification harder than with a well-defined feature, there are two examples nearby that make the task easier. To the north is beautiful **Eudoxus**, a 68km diameter crater with a complete rim and fine internal terraces. These lead down to a bumpy floor with several hills clustered together in the centre. To Alexander's south west lies the smaller form of **Calippus**, a 33km diameter crater with steep sides which lead down to a relatively flat floor. These features provide a good way to navigate to Alexander.

Eudoxus itself is outshone by 88km **Aristoteles** to the north. This is another well-defined and impressive feature with prominent terraced rim ramparts that lead down to a flat floor. A number of hills appear in the middle, the largest two being somewhat offset towards the south of the crater's centre.

There's a fine crack in the surface of Mare Serenitatis located on the mare floor immediately south of Alexander. Known as **Rima Calippus**, this feature requires a 300mm or larger telescope to see well. It is 2.4km wide and runs for approximately 40km, following a curved path initially southwest before turning south.

The peaks that define Alexander's western rim are elevated sufficiently over the crater's floor to catch the early light of the lunar dawn before the surrounding area. At such times, through a telescope the individual peaks appear like tiny stars arranged in a beautiful arc. This necklace of star-like points is a clair obscur effect known as **Alexander's Beaded Rim**. This occurs at a lunar co-longitude value of 342.1° about six days after new Moon. Lunar or selenographic co-longitude is a measure of the position of the morning terminator – basically the line marking lunar sunrise. This line is at zero degrees at the first quarter phase and increases in value to 90° at full Moon, 180° at last quarter and 270° at new Moon. Its value can be obtained by various means, examples being the Virtual Moon Atlas (**www.ap-i.net/avl/en/start**) and WinJupos (**http://jupos.org/gh/download.htm**).

The peaks that define Alexander's western rim appear like tiny stars arranged in a beautiful arc



Alexander's Beaded Rim is an optical effect that occurs when the crater's peaks are illuminated by the lunar dawn

PETE LAWRENCE X 5

COMETS AND ASTEROIDS

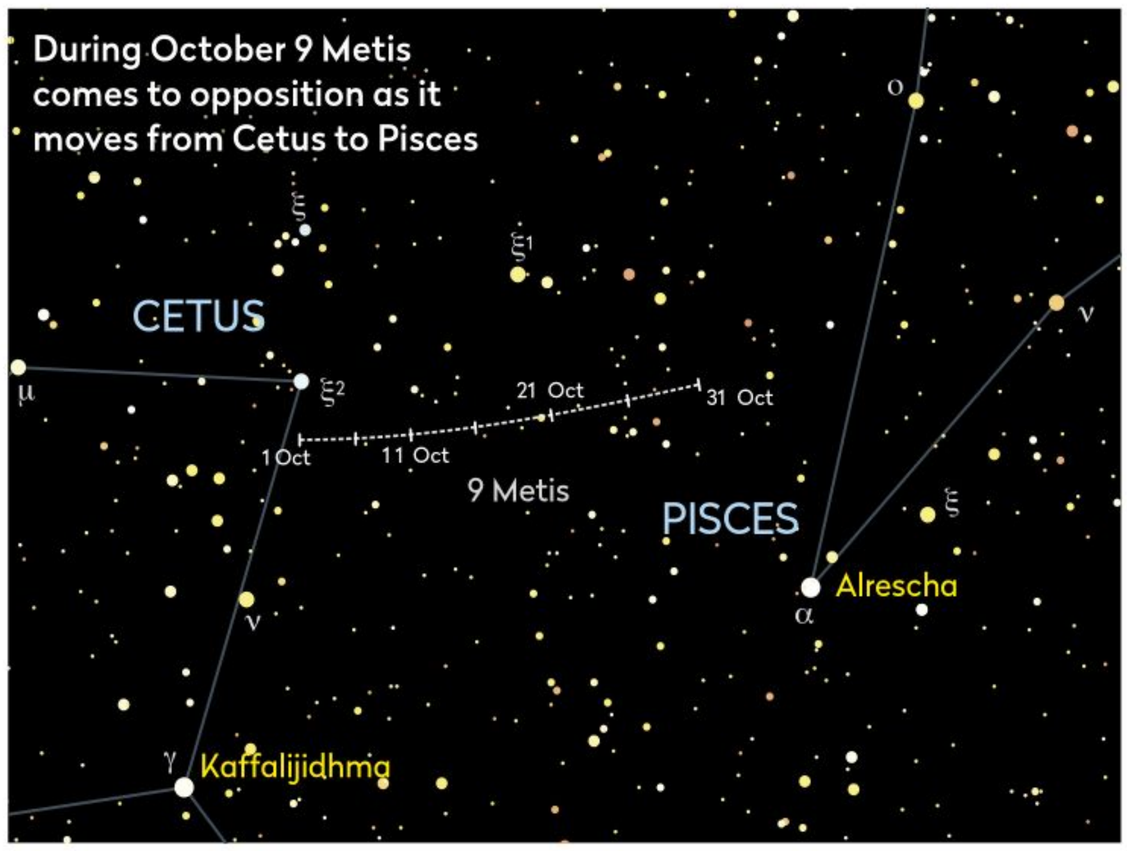
Asteroid 9 Metis can be located by using the old-fashioned blink technique

Asteroid 9 Metis reaches opposition on 25 October in Cetus the Whale, just nudging into Pisces the Fishes by the end of the month. It begins the month just to the west of the head of Cetus, south-southeast of mag. +4.3 Xi^2 Ceti. From here it tracks roughly west-southwest, crossing the border into Pisces on 28 October and ending the month roughly 4° to the north of Alrescha (Alpha (α) Piscium).

At the start of its track on 1 October, Metis appears at mag. +9.3, brightening to a peak of mag. +8.6 on 22 October, a value it retains for the rest of the month. The maximum brightness it can achieve is mag. +8.1, so this is a reasonable opposition.

This is a main belt asteroid, thought to be a core remnant of a larger body, broken up during a collision in an earlier period of the Solar System. It's a large siliceous or S-type asteroid measuring 222x195x140km. Siliceous asteroids have a stony or mineralogical composition and are the second most common type of asteroid after C-types which contain a large amount of carbon.

Metis is likely to have a pointed end and a broad end, a result derived by measuring the object's reflected light variation. Hubble Telescope images also agree with this shape model. Metis takes 3.69 years to complete an orbit of the Sun. Its orbital distance varies from a maximum value (aphelion) of 2.68 AU to a minimum (perihelion) of 2.10 AU.



Metis was discovered on 25 April 1848 by Irish astronomer Andrew Graham. He used a 3-inch wide-field telescope designed for comet searches. The best way to 'see' Metis is to use the old blink technique. Draw or photograph the star field over a few nights. If you compare each result by aligning and flicking between them, Metis will reveal itself as a consequence of its relative motion against the background stars.

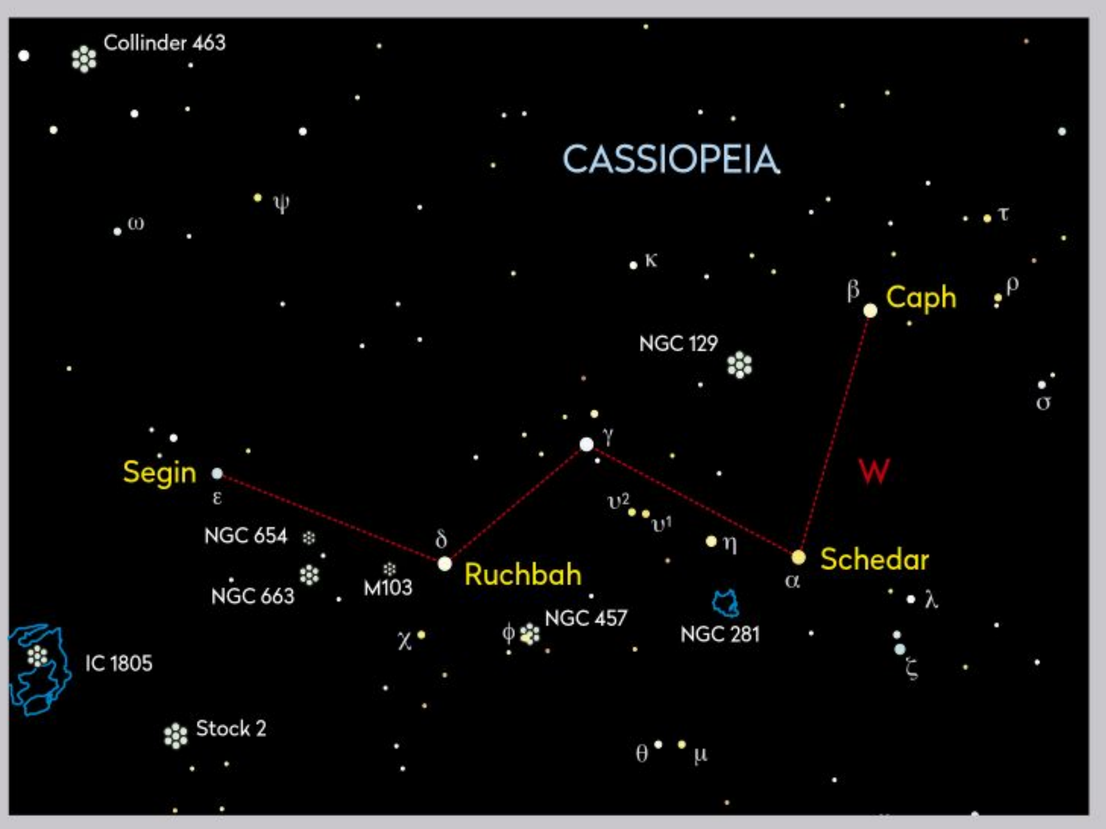
STAR OF THE MONTH

Schedar, the shining heart of Cassiopeia

From the UK, the W-shaped constellation of Cassiopeia appears circumpolar, meaning it never sets. Its shape is distinctive and easy to see. Being circumpolar means Cassiopeia is always visible when the sky is dark and clear. Its pattern can also be seen to do a complete rotation around the North Celestial Pole, approximately marked by Polaris (Alpha (α) Ursae Minoris). However, it's only when at its lowest point due north that Cassiopeia appears as a W the right way up. The constellation represents the Seated Queen and the name of the star Schedar (Alpha (α) Cassiopeiae) translates as 'breast', indicating its position in the heart of the Queen.

Schedar appears second from the right with the W the right way up. It shines at mag. +2.2 and has a spectral type of K0 IIIa: an orange-hued (K0) luminous giant star (IIIa). Its diameter is slightly in excess of 42 times that of our own Sun.

Schedar lies 228 lightyears from the Sun, about four times farther than Caph (Beta (β) Cassiopeiae) which from Earth has a similar brightness of mag. +2.3. Both stars are slightly variable, Schedar varying between mag. +2.20 and +2.23, Caph between mag. +2.41 and +2.36. Schedar rotates at a speed of 21km/s and takes 102 days to turn once on its axis.

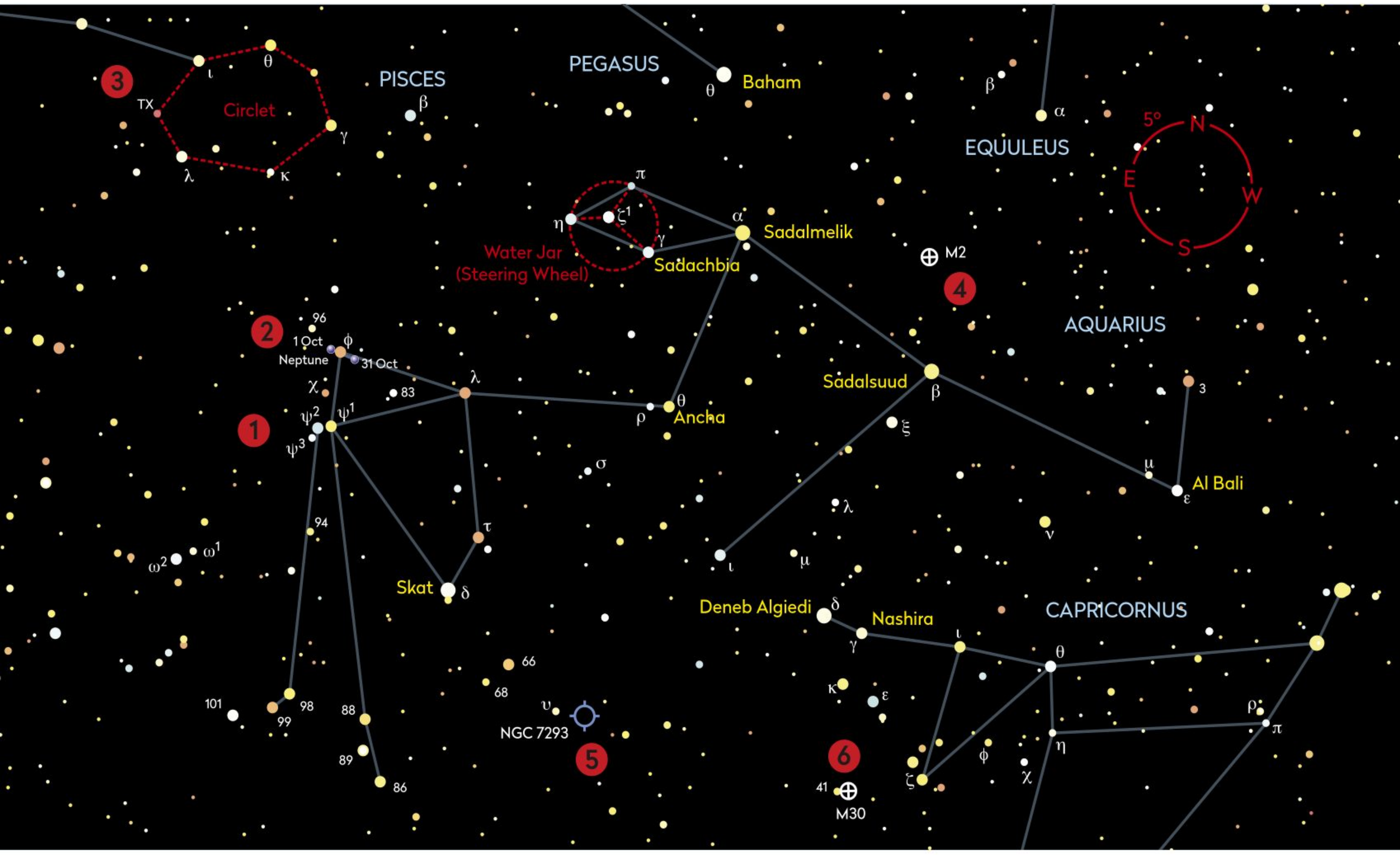


▲ **W-shaped Cassiopeia is always above the UK's horizon**

This giant star has an estimated mass of five times that of our Sun and, as must be the case for higher mass stars, its burn rate is high. We can estimate Schedar's age is in the range of 100–200 million years.

BINOCULAR TOUR With Stephen Tonkin

A collection of the night sky's most colourful objects, including one of its reddest



1. Psi Aquarii star field

10x 50 Colourful star fields are a delight in binoculars and this one is particularly interesting. With the exception of class O, it contains bright stars of the main spectral classes (BAFGKM), so you can use it to get a sense of the colours of each class. Psi-2 (ψ-2) Aqr is a B, ψ-3 is an A, 83 and 96 are Fs, 94 is a G, ψ-1 is a K, and Chi (χ) and Phi (ϕ) are Ms. ☐ **SEEN IT**

2. Neptune

10x 50 Shining at mag. +7.8, the planet Neptune is very easy to see in binoculars as long as you know exactly where to look for it. It starts October a mere 40 arcminutes from Phi (ϕ) Aqr in the direction of Lambda (λ) Aqr, and moves the same distance in the same direction as the month progresses. Don't expect to see a disc; it appears stellar in binoculars, but you can identify it because it moves slightly from night to night. ☐ **SEEN IT**

3. TX Piscium

10x 50 The easternmost star in the southern circlet of Pisces is one of the reddest in the night sky, the slightly variable (mag. +4.8 to mag. +5.2) TX Piscium. TX is a carbon star: it pulsates in size and as it contracts it throws off layers of soot that cause it to dim slightly. You may notice that it seems to get brighter as you look at it, a phenomenon called the Purkinje effect. ☐ **SEEN IT**

4. M2

10x 50 The globular cluster M2 is easy to find: it forms a right-angled triangle with Sadalsuud (Beta (β) Aquarii) and Sadalmelik (Alpha (α) Aquarii) which are due south and east of it respectively. It is obvious in a sparse region of sky, and you can see it as Charles Messier described it: "a nebula without stars". If you use averted vision in good sky conditions, you might notice that it appears oval and slightly granular. ☐ **SEEN IT**

5. NGC 7293

15x 70 You'll need a good southern horizon, along with a transparent sky and full dark-adaptation to spot NGC 7293, the Helix Nebula. Look 10° south of Sigma (σ) Aquarii and you'll find Upsilon (υ) Aquarii. A little more than 1° to the west, you should see a faint circular patch that is a similar size to M2. ☐ **SEEN IT**

6. M30

15x 70 If you ever attempt a Messier marathon (observing all 110 Messier objects between dusk and dawn), your final morning twilight object will be this little globular cluster, so you'll need to have practised finding it. Autumn evenings are a good time to start. Identify 41 Capricorni, which lies just over 3.5° east of Zeta (ζ) Capricorni. Half a degree back towards Zeta you should see the cluster, looking like a slightly defocused star. ☐ **SEEN IT**

☑ Tick the box when you've seen each one

PETE LAWRENCE X 3

THE SKY GUIDE CHALLENGE

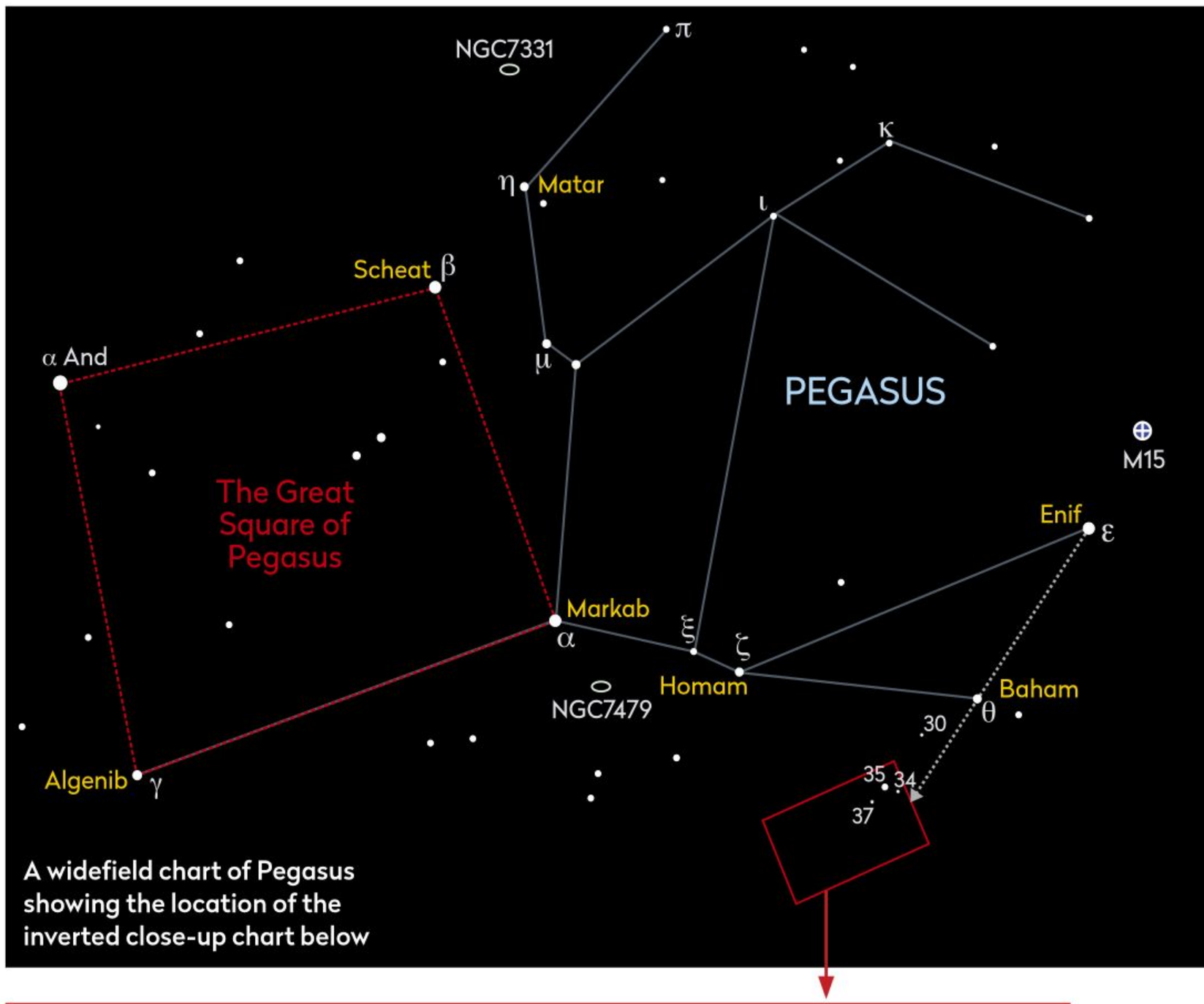
For this tricky target – the Einstein Cross – you'll need access to a large telescope

This month's Sky Guide Challenge lives up to its name because we're asking you to locate a peculiar object in the constellation of Pegasus known as the Einstein Cross. There's no point in trying to sugarcoat things here because the Einstein Cross is listed at mag. +16.8 and has an apparent size of less than 2 arcseconds. In order to stand any chance of seeing it visually, you'll need very dark skies and a large scope with an aperture over 18 inches (457mm). In this respect the Einstein Cross may be better suited for an imaging setup.

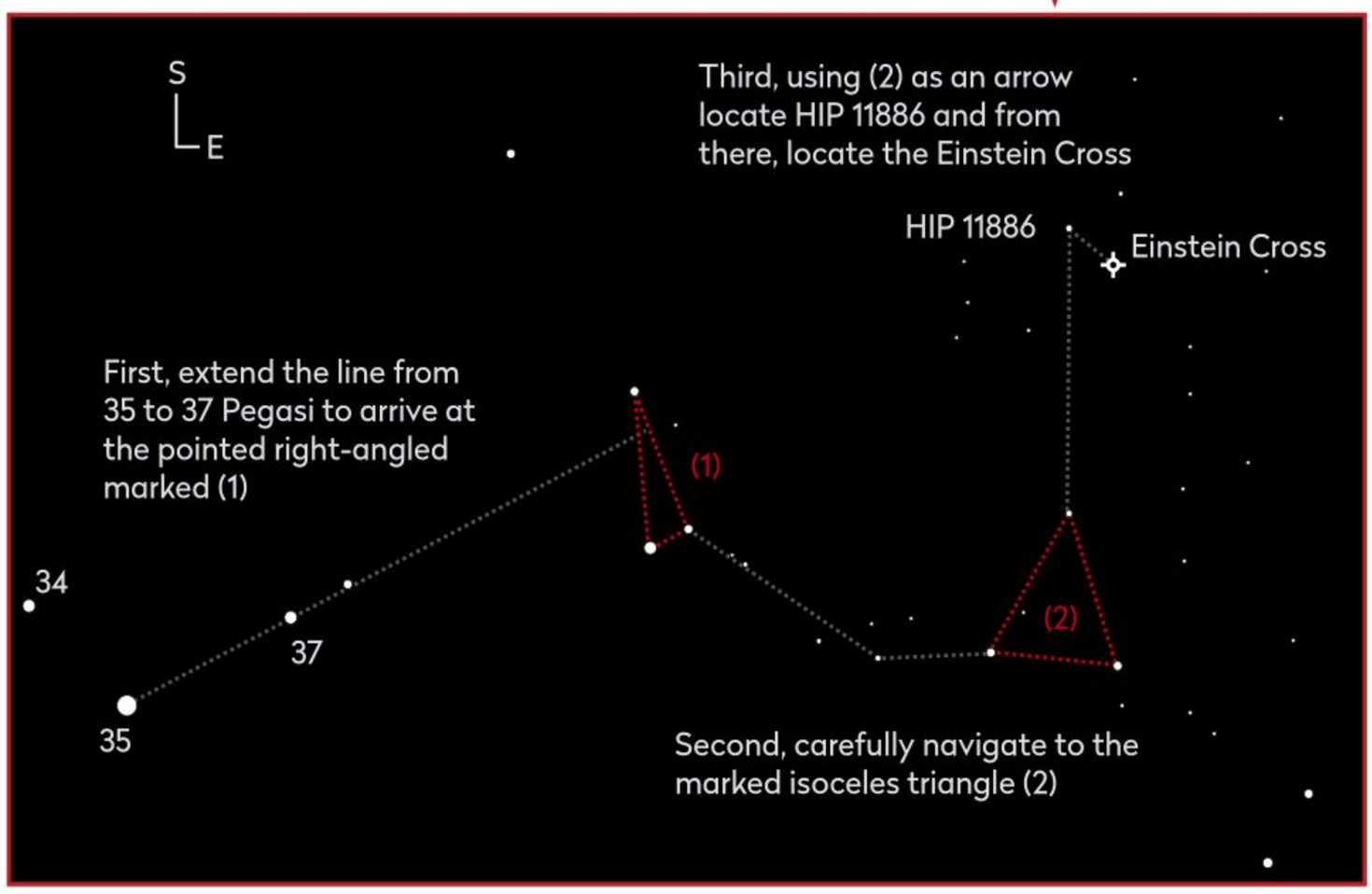
The Einstein Cross appears as five 'blobs' of light, a faint one in the centre, one above, one below and one each side. Amazingly this represents just two objects: a foreground galaxy known as ZW 2237+030 and a distant quasar catalogued as QSO 2237+0305. The actual parts of the quasar we can see are identified as QSO 2237+0305 A through D. These designations mark the outer light spots of the cross. The quasar has four designations because the gravitational field of the 400 million lightyear-distant foreground galaxy is lensing its light to produce four images of it. The more distant quasar is estimated to be 8 billion lightyears away.

The best way to approach this challenge is to split it in two. The first task is to try to either see or image the Einstein Cross without any concern for capturing its structure. For modern imaging setups, mag. +17 is achievable and shouldn't present too much difficulty. Visually, the only way to see the cross is to gain access to a large telescope. If you don't have one yourself, you could always try your local astronomical society. Even if they don't have one, they might still be able to recommend someone who has.

If you get the bug you'll find yourself continuously coming back to the Einstein Cross to try for a better result



A widefield chart of Pegasus showing the location of the inverted close-up chart below



▲ **Three steps: an inverted view (south up) reveals how to track down the Einstein Cross**

Once you've managed to image the Einstein Cross as a faint patch of light, the next task is to try to pull out its structure. For this you'll need to combine a large aperture and imaging technology. The minimum aperture requirement will probably be around 300mm, but a long focal length and good seeing are also required. Aim for a focal length around the 3 metres mark to start and experiment from there. The most likely result will be a blob of light which hints at the cross-shape on magnified inspection. Splitting the lensed components may be asking too much. Regardless, the Einstein Cross is an object to savour and take your time over. If you get the bug you'll find yourself continuously coming back to it to try for a better result.

DEEP-SKY TOUR

From Kemble's Cascade, a colourful waterfall of stars, to the dust-shrouded 'Hidden Galaxy'

1 Kemble's Cascade

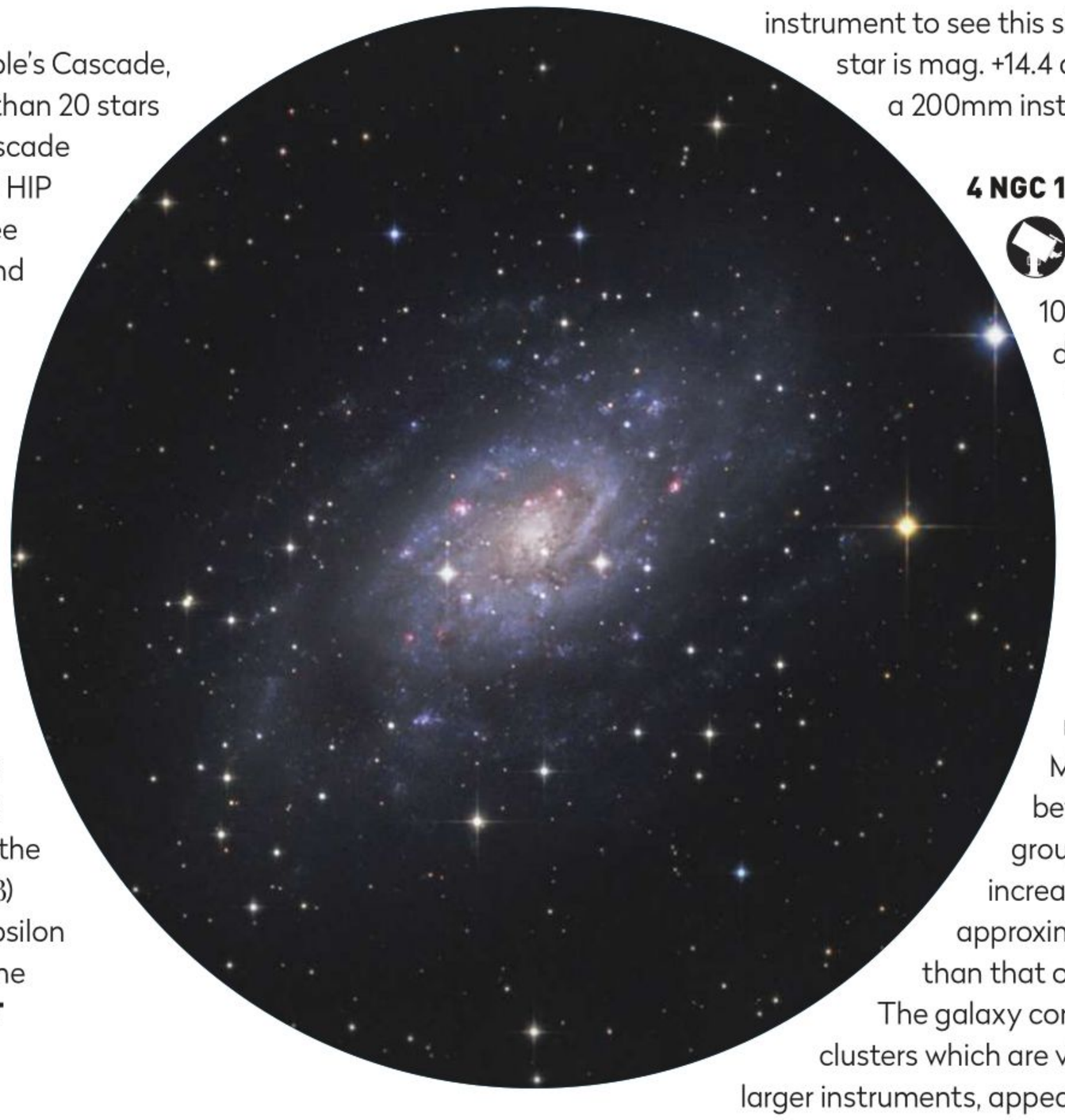
Our first stop is Kemble's Cascade, an asterism of more than 20 stars in Camelopardalis. The cascade has at its centre, mag. +4.9 HIP 18505 and extends a degree from this star northwest and 1.5° to the southeast. The main 'structure' is formed from stars between mag. +7 and +8 but fainter members down to mag. +10 help reinforce the straight-line appearance. It rewards a low-power view and there are some lovely star colours. Look for the two orange members in the northwest leg of the cascade. Locate the cascade by extending the line between Caph (Beta (β) Cassiopeiae) and Segin (Epsilon (ε) Cassiopeiae) for the same distance again. ☐ **SEEN IT**

2 NGC 1502

From Kemble's Cascade, our next target is easy to find. NGC 1502 is a mag. +5.7 open cluster located at the southeast end of the line of stars that forms the cascade. Kemble's Cascade is often described as appearing like a waterfall of stars, pouring into a splash pool represented by NGC 1502. The cluster appears to contain around 25 stars through a 300mm scope, two of which are conspicuous because they are brighter than the rest. These are components of the double star Struve 485, the pair being known as Struve 485 AE. The cluster has an apparent diameter of 20 arcminutes and is 2,700 lightyears away. ☐ **SEEN IT**

3 NGC 1501

Next, look 1.4° to the south of NGC 1502. Here you'll find the misleading planetary nebula NGC 1501. The 'misleading' comment refers to the fact that although it's listed as a mag. +13.3 object, it's easy to spot, appearing brighter than its catalogue listing. It has a diameter of 52 arcseconds, a little larger than Jupiter when at opposition. It resembles the Ring Nebula, M57, although you need a larger instrument to see this similarity. The central star is mag. +14.4 and can be seen with a 200mm instrument. ☐ **SEEN IT**



▲ Photo finish: you'll see the hint of of a spiral in galaxy NGC 2403 with scope apertures over 300mm

4 NGC 1569

Next is NGC 1569. This is a dwarf irregular galaxy, 10.96 million lightyears distant. It's listed as a mag. +11.2 object but it also has a large apparent size of 3.7x1.8 arcminutes. Spreading the galaxy's light over this area results in a lower surface brightness around mag. +13.1. NGC 1569 is a member of the IC 342 or Maffei 1 Group. Interactions between members of the group has resulted in an increased star formation rate, approximately 100 times higher than that of our own Milky Way. The galaxy contains several super star clusters which are visible to 200mm or larger instruments, appearing reminiscent of the condensation found at the galaxy's core. ☐ **SEEN IT**

5 IC 342

Known as the 'Hidden Galaxy', IC 342 is located 4.4° north of the northeast end of Kemble's Cascade, midway between Gamma (γ) Cam and HIP 17884. The nickname comes from its proximity to the Milky Way. Intervening dust in our own Galaxy makes more distant galaxies hard to observe properly. IC 342 lies at a distance of 10.7 million lightyears and has a bright apparent magnitude of +9.1. It's a face-on spiral galaxy and one of the brightest members of the IC 342 Group. It has a large apparent size, measuring 21.4x20.9 arcminutes. If it weren't for the foreground curtain of dust, IC 342 would be one of the finest galaxies in the night sky. ☐ **SEEN IT**

6 NGC 2403

Our final target takes us to the eastern side of Camelopardalis, a large sweep of 16° to the east of mag. +4.3 Alpha (α) Cassiopeiae. Here you'll find another fine object in Camelopardalis, the bright intermediate spiral galaxy, NGC 2403. An intermediate spiral galaxy is one which has a structure between a barred and unbarred spiral galaxy. It's listed as a mag. +8.4 object, but its surface brightness is lower thanks to its nearly face-on orientation, in the region of mag. +13.9. It is a decent size, appearing as a grey smudge of apparent dimensions 15x6 arcminutes in small scopes. It's a rewarding object as aperture increases. ☐ **SEEN IT**

MICHAEL DEGER/CCDGUIDE.COM, CHART BY PETE LAWRENCE

This Deep-Sky Tour has been automated
ASCOM-enabled Go-To mounts can now take you to this month's targets at the touch of a button, with our Deep-Sky Tour file for the EQTOUR app. Find it online.

More **ONLINE**

Print out this chart and take an automated Go-To tour. See page 5 for instructions.

CAMELOPARDALIS

LYNX

PERSEUS

NGC 2146

HIP 24254

NGC 1560

IC 356

IC 342

IC 1805

PGC 74110

NGC 1027

Berkeley 65

IC 1848

Trumpler 3

Collinder 33

Collinder 34

Collinder 464

HIP 17884

Kemble's Cascade

HIP 18505

NGC 1961

NGC 1569

NGC 1502

NGC 1501

Tombaugh 5

NGC 2366

NGC 2403

PuWe 1

NGC 1444

NGC 1496

NGC 1528

NGC 1513

NGC 1545

α

β

γ

15

2

08h00m

07h00m

06h00m

05h00m

04h00m

03h00m

+70°

+60°

+50°

5°

2°

N

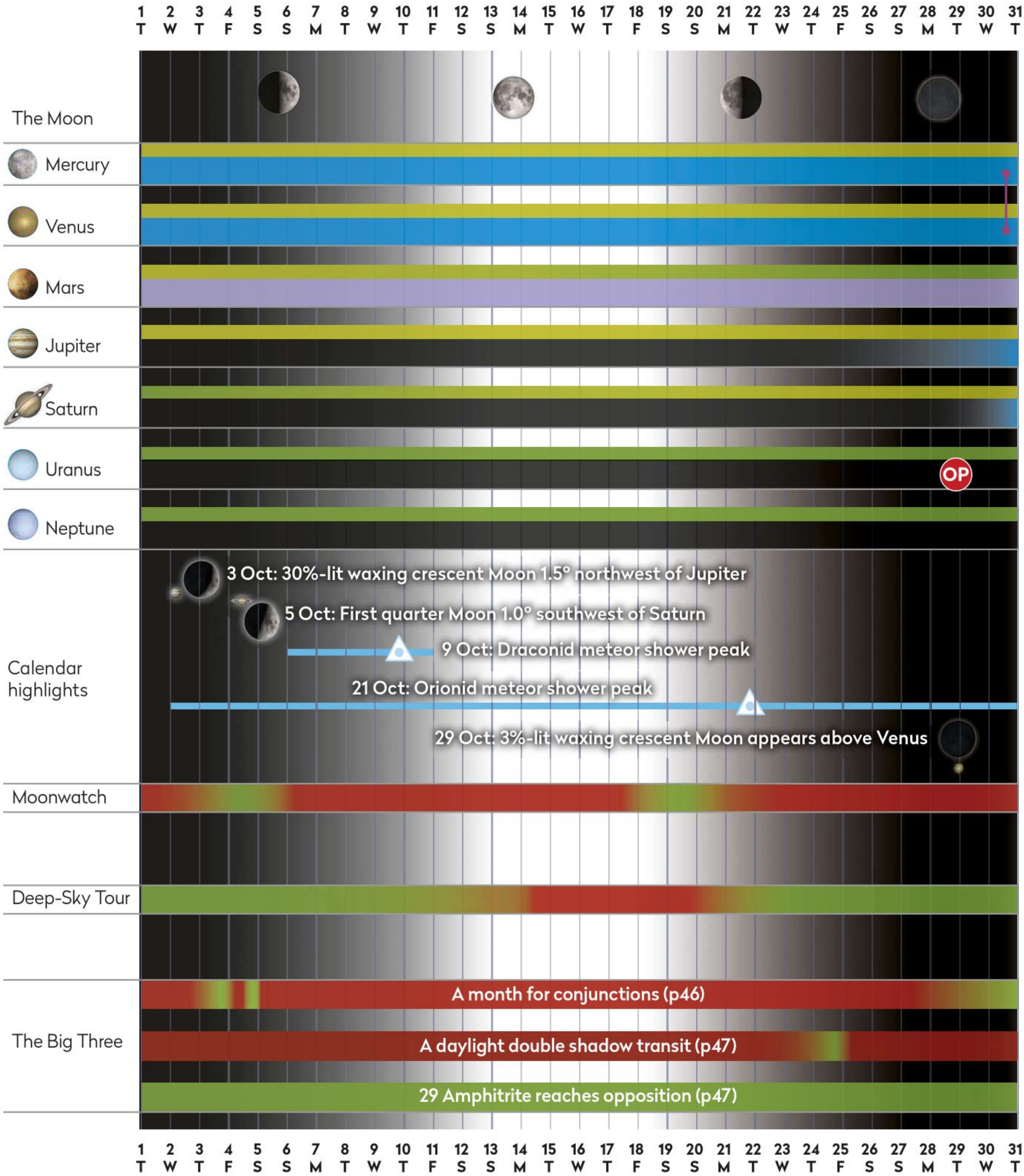
E

S

W

AT A GLANCE

How the Sky Guide events will appear in October



KEY

Observability

Optimal | Poor

Best viewed

Morning twilight | Daytime | Evening twilight | Night

Sky brightness during lunar phases

Dark (first quarter) | Light (full Moon) | Dark (last quarter) | Total darkness (new Moon)

IC Inferior conjunction (Mercury & Venus only)

SC Superior conjunction

OP Planet at opposition

Meteor radiant peak

Planets in conjunction

Full Moon

First quarter

Last quarter

New Moon

CHART BY PETE LAWRENCE

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BBC Sky at Night MAGAZINE

Ghostly presence: look at the sky in the darkness before dawn in mid-October to catch a glimpse of the cone-shaped Zodiacal Light

LOOKAOD/ISTOCK/GETTY IMAGES

Chasing the ZODIACAL LIGHT

The faint Zodiacal Light is as elusive as it is alluring. **Will Gater** goes in search of this ethereal celestial sight

On a cool night in late February at one of my favourite observing sites in the heart of Exmoor National Park, I take in the earthy smell of the moorland. Looking west, an hour after sunset, I see vibrant strips of orange and blue adorning the horizon.

I've come here because for a few weeks at this time of year – and indeed around October, when you are probably reading this – the alignment of the heavens is just right to spy one of the Solar System's most elusive sights. Not an asteroid, nor a planet, nor a comet, but something far larger. And while it may be elusive, if the conditions are good you don't even need a telescope to see it.

I've come to hunt the 'Zodiacal Light', and as twilight fades I can see its unmistakable form emerging against a star-filled sky.

To the naked eye it appears as a narrow cone, or elongated triangle, of diffuse light extending up at an angle from the horizon. It has something of a ghostly quality about it, in that at first it can come and go from your vision until your eye becomes trained to recognise its shape and presence. Indeed the practice of averted vision, commonly used by deep-sky observers – where you look slightly away from a celestial target in order to allow light to fall on the eye's more-sensitive rod cells – can help to reveal the faint glow.

From a dark-sky site and with a suitably dark adaptation, though, it's easily visible with direct vision glowing at a broadly comparable brightness to some of the fainter swathes of the summer Milky Way.

And that is why many astronomers, even highly experienced ones, have never seen the Zodiacal Light. The celestial show is completely ▸

Planetary positioning: sometimes the likes of Mercury, Venus and Mars can appear embedded within the Zodiacal Light

▸ hidden by the light-fogged skies of our suburban areas. Only truly dark skies can reveal its beauty. What, then, causes this ethereal light and why does it have the shape it does? The answer lies scattered throughout the inner Solar System.

When a comet ventures into the inner Solar System, the warmth of the Sun can heat its surface causing ices to sublimate and dust particles to be ejected into space. It's this process that creates the exquisite tails that some comets develop during their brief moments in the Sun. Though their passages through the inner regions of our planetary neighbourhood are fleeting, these icy visitors do leave a longer-lasting legacy, literally, in the form of the flecks of dust they release.

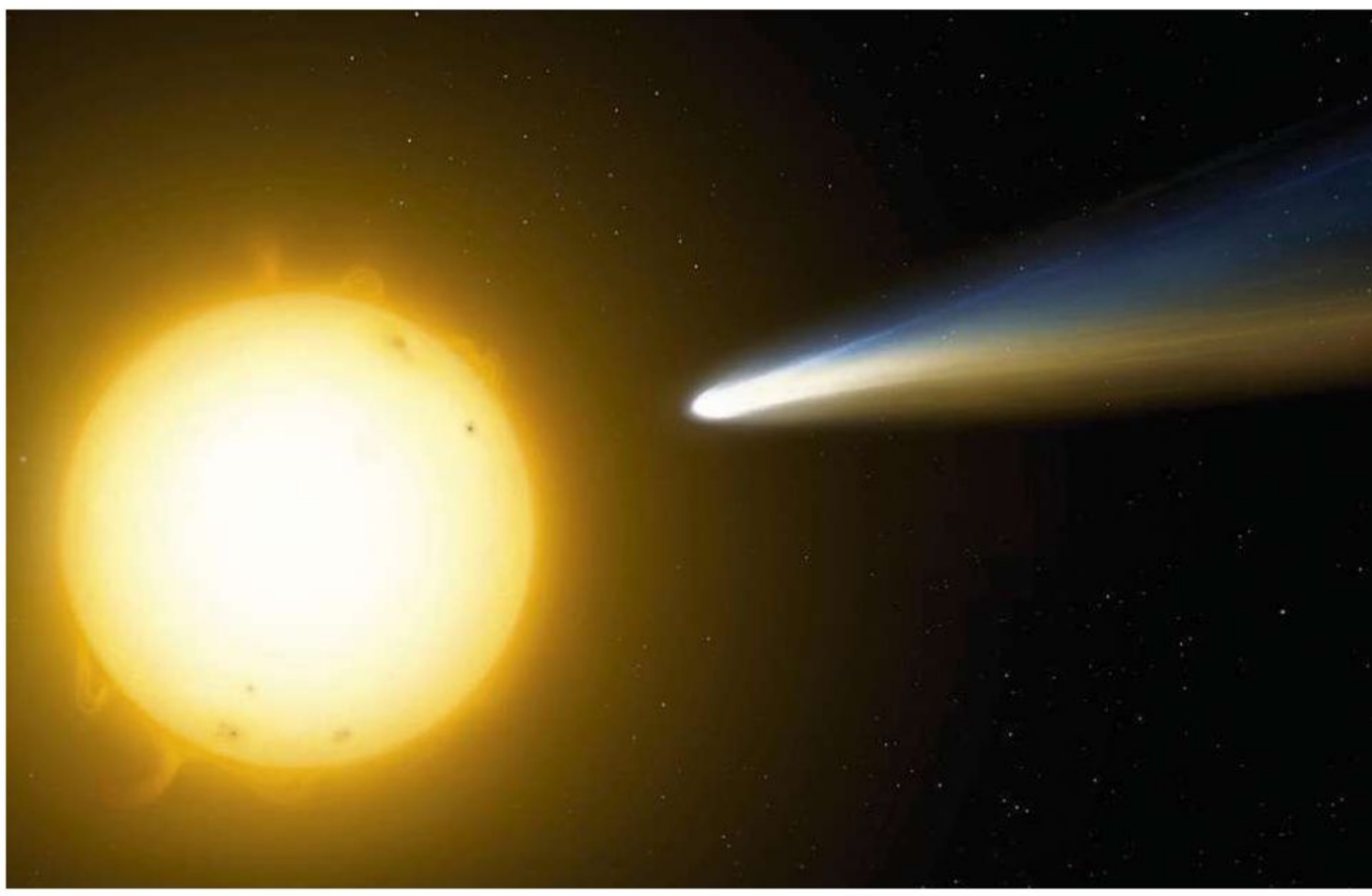
As the dust settles

This dusty debris disperses out into the Solar System, creating a vast cloud of particles within the orbital plane of the planets. When we observe the faint glow of the Zodiacal Light we're seeing sunlight scattering off this interplanetary material.

Because the dust is located broadly within the plane of the Solar System, the Zodiacal Light appears in the same location in the night sky as the ecliptic – an imaginary line that marks out the path of the Sun through the constellations during the year. This path passes through the 'zodiacal' constellations, hence the name Zodiacal Light.

For the best views of the Zodiacal Light we need to observe when the ecliptic is high in the sky and at a large angle with respect to the horizon. This happens during two Zodiacal Light observing 'seasons' each year. The first occurs after sunset around February time, while the second happens in the darkness before dawn around mid-October.

For the evening apparition in February, the optimal time to go looking is around the end of astronomical twilight. The light will loom up over the western horizon. For the morning apparition, in October, when it will be over the eastern horizon, the show will be drawing to a close by the time of the start of astronomical twilight.



▲ **Trailblazing: dust from comets creates a vast cloud of particles that scatters sunlight**

Dark skies are obviously key to spotting the faint glow, but if you're planning an observing trip make sure to time it for when the Moon is out of the way, as even a thin lunar crescent located among the Zodiacal Light can spoil the view. Transparent skies will also help.

Before any observing trip, check that there will be no prominent light-pollution domes along the line of sight towards the base of the Zodiacal Light as this can ruin your chances. To do this, use a program like Stellarium to find the azimuth of the point where the ecliptic meets the horizon at the time that you'll be looking on your chosen observing night. Then, using a good map, see if there are any major towns or cities – even distant ones – along that compass bearing from your planned observing location. ▸

MIKE CAVAROC/ALAMY STOCK PHOTO, SCIENCE PHOTO LIBRARY/ALAMY STOCK PHOTO, WILL GATER X 8

Tips for photographing the glow

The ethereal light can create a unique image

The Zodiacal Light is an elusive quarry to track down visually, but can also be a rewarding target to capture on camera, especially when incorporated into nightscape astrophotography. You'll need to plan carefully to get the best shots, so I've broken down the process with some tips on how to go about chasing this ethereal glow with a DSLR.

1. SCOUT A (SAFE) LOCATION

To get the best chance of capturing the Zodiacal Light you'll need a clear, low horizon to either the east or west – depending on when you're imaging. Open, or high, ground away from objects like buildings, treelines, hedges and tall hills can be a good place to start.

2. AVOID LIGHT POLLUTION DOMES

Pay particular attention to where any domes of light pollution – from distant towns or cities – might be on your horizon. Try to avoid shooting from locations where these would be aligned with where the 'base' of the Zodiacal Light sits, as they can mask its presence.

3. TRACK THE SKIES

With a fast, prime, wide-angle lens and a high ISO setting on a DSLR, it's perfectly possible to get decent Zodiacal Light images using just a static tripod. But in order to use lower ISO settings – and therefore get a cleaner image – a motorised mount is the way to go.

4. CHOOSE YOUR LENS WISELY

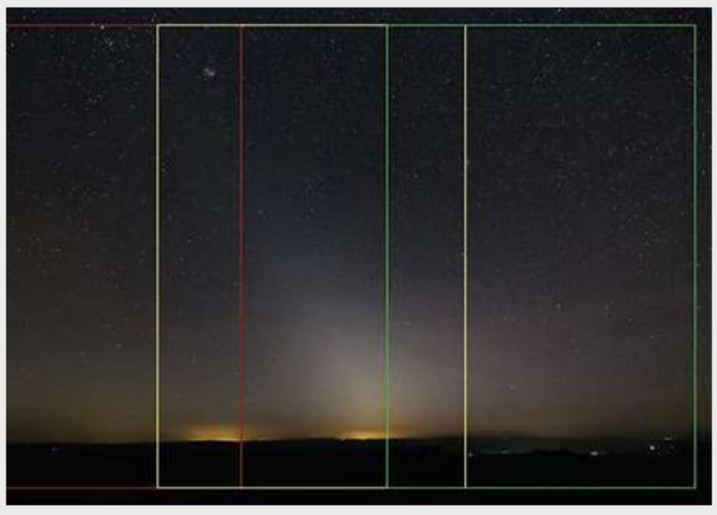
The Zodiacal Light extends across a huge portion of the sky. This means you'll want to think carefully about how you might frame it. Ideally, you'll need a lens–DSLR combination that provides a field of view of at least 50° on the long side to capture the glow in context against the darker sky.

5. STOP DOWN TO AVOID VIGNETTING

For the clearest Zodiacal Light shot you'll want an evenly illuminated field of view, with minimal vignetting (darkening of frame corners). This may mean you have to reduce the aperture of your lens. Minor vignetting can be processed out, but getting the best data in camera is preferable.

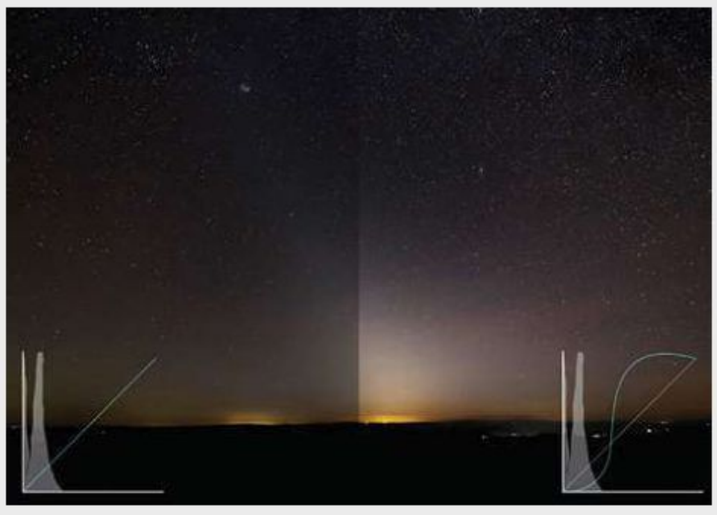
6. BRACKET YOUR EXPOSURES

There's a sweet spot for photographing the Zodiacal Light – where there is a nice balance between the background sky darkness and the prominence of the base of the 'cone' – that only lasts a little while. Bracket your exposures, either manually or using the pre-programmed function.



7. MOSAIC IF NECESSARY

If your DSLR and lens combination doesn't quite have a field of view wide enough to encompass the whole Zodiacal Light cone, take several images to make a mosaic later in image-editing software. Remember to leave plenty of overlap so you don't have any gaps in your final composited picture.



8. STRETCH IT OUT

For the Zodiacal Light one of the simplest and most effective post-capture enhancements is a 'curves' adjustment – available in most image-editing programs. To do this, open the curves tool and tweak the diagonal adjustment line so it resembles a shallow, diagonal S.

Light entertainment

Four UK locations where you have a good chance of seeing the Zodiacal Light

EXMOOR NATIONAL PARK

Located across north Devon and west Somerset, Exmoor National Park is famous across the world for its International Dark Sky Reserve. With views out across the rural landscape of north Devon to the west it's an ideal location to look for the Zodiacal Light during its evening apparition.

MID-WALES

The spectacular landscape of mid-Wales offers superb views of the night sky alongside its magnificent daytime scenery. With dark skies readily accessible and a location far enough away from the heavily light-polluted south coast, it's the perfect spot to go looking for the Zodiacal Light's gentle glow.

CORNWALL

Away from the lights of its largest towns, Cornwall offers some of the UK's darkest night skies. With many places offering views out across the Atlantic, this is another area that's well suited to hunting the Zodiacal Light during its evening apparition. But take great care when imaging from coastal locations.

GALLOWAY FOREST PARK

Towering trees and stunning mountain scenery combined with inky-black night skies make Galloway Forest Park, Scotland, a superb location for nightscape astrophotography. From here there are lots of compositional options to choose from, whether you're shooting after sunset or in the darkness before sunrise.

► **The Gegenschien is very faint, but can just be seen in the centre of this image, taken in the skies over Exmoor**

Will Gater is an astronomy writer and presenter. Follow him on Twitter at @willgater or visit willgater.com

► If you're lucky, some of the planets might be positioned in such a way as to appear embedded within the zodiacal glow – something that really brings home the geometry of the phenomenon.

Tricky target

Back on Exmoor, the bright base of the Zodiacal Light has sunk into the west, so I pack up and decide to move to another observing site out of the breeze, where I can set up some imaging kit for the night. Buoyed by the star-flecked views of the Zodiacal Light, I try to track down its rarely-seen companion: the 'Gegenschein', or 'counter glow'.

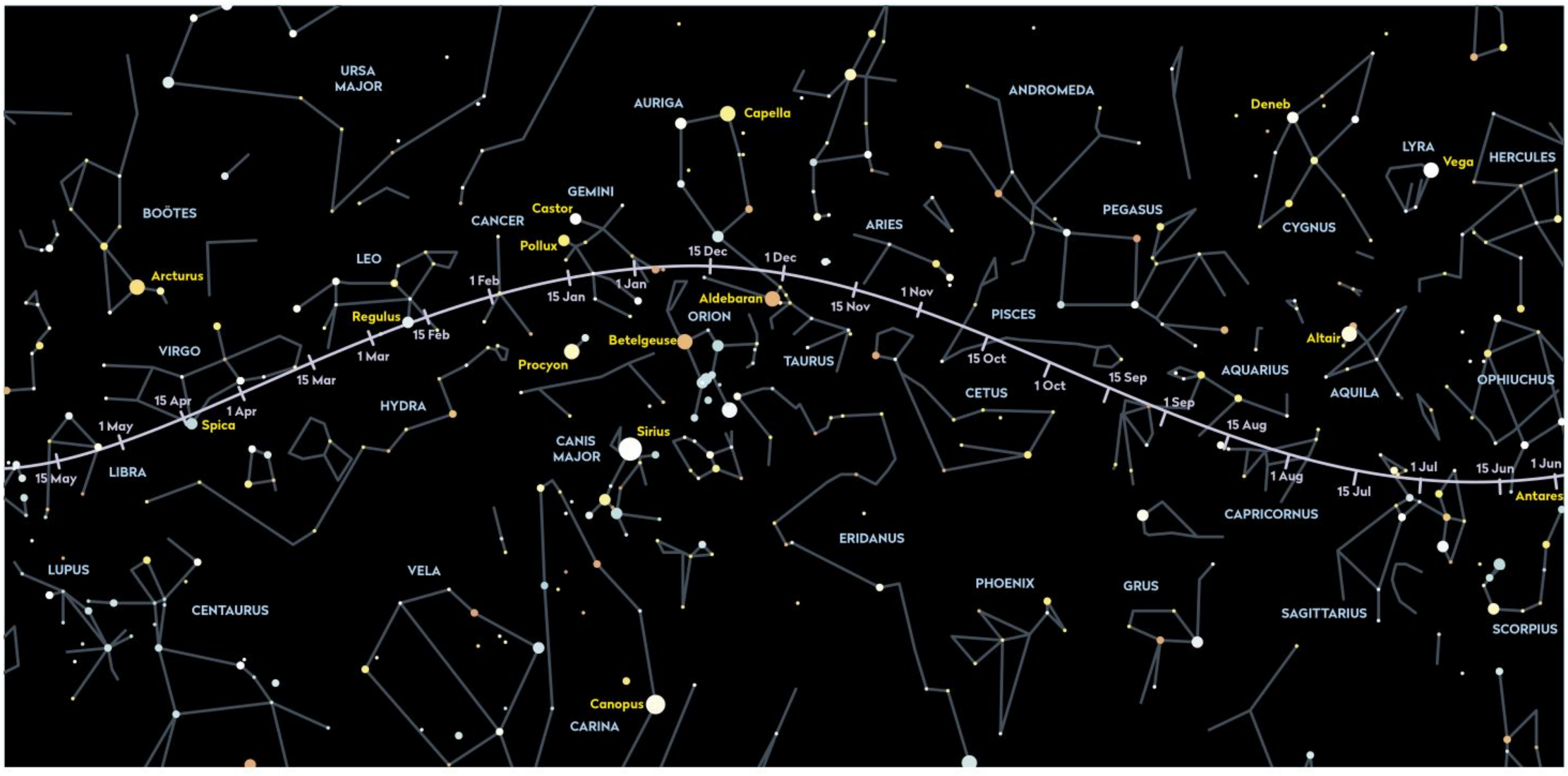
This phenomenon is much fainter than the Zodiacal Light and observing it requires a good eye as well as very dark and transparent skies. It's formed in much the same way too, except it results from sunlight bouncing backwards off the interplanetary dust – the reason why it appears as an extraordinarily dim patch of light at the anti-solar point, the position on the night sky directly opposite the Sun.

Even though I know the area on the sky where the Gegenschein should be, after more than an hour of dark-adaptation and careful observation I can't claim anything like a definitive sighting. I've set my DSLR up to photograph the region though, and it did catch something (pictured above). Later processing of the images would reveal an unmistakable bright area of sky in precisely the right place.

On this night, then, the camera won. But, in a way, I quite like the thought that there's something rare and ethereal still on my observing tick-list after all these years. It'll surely make that moment I finally do see the Gegenschein's elusive glow all the more thrilling.

Getting the Gegenschien

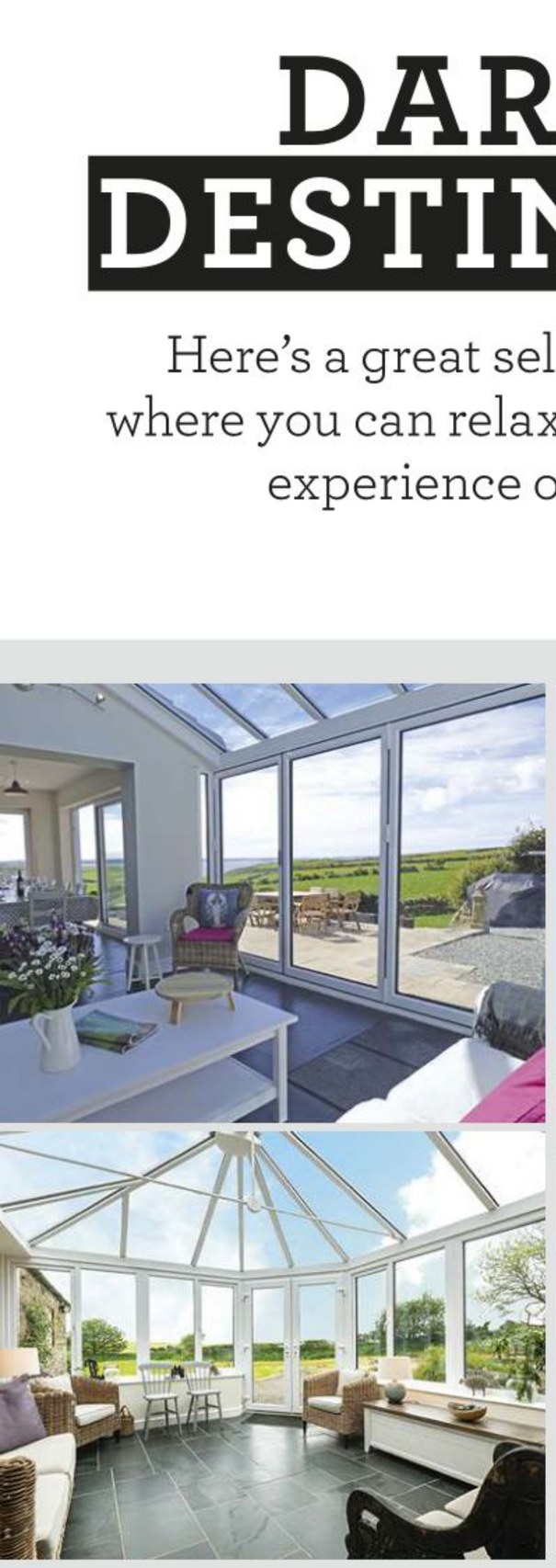
The Gegenschein's location matches the position of the anti-solar point, found in the nighttime sky; this is the point on the celestial sphere that lies directly opposite the position of the Sun in the sky. Here we've plotted the Gegenschein's position as it moves through the constellations during the year, to help you track it down.

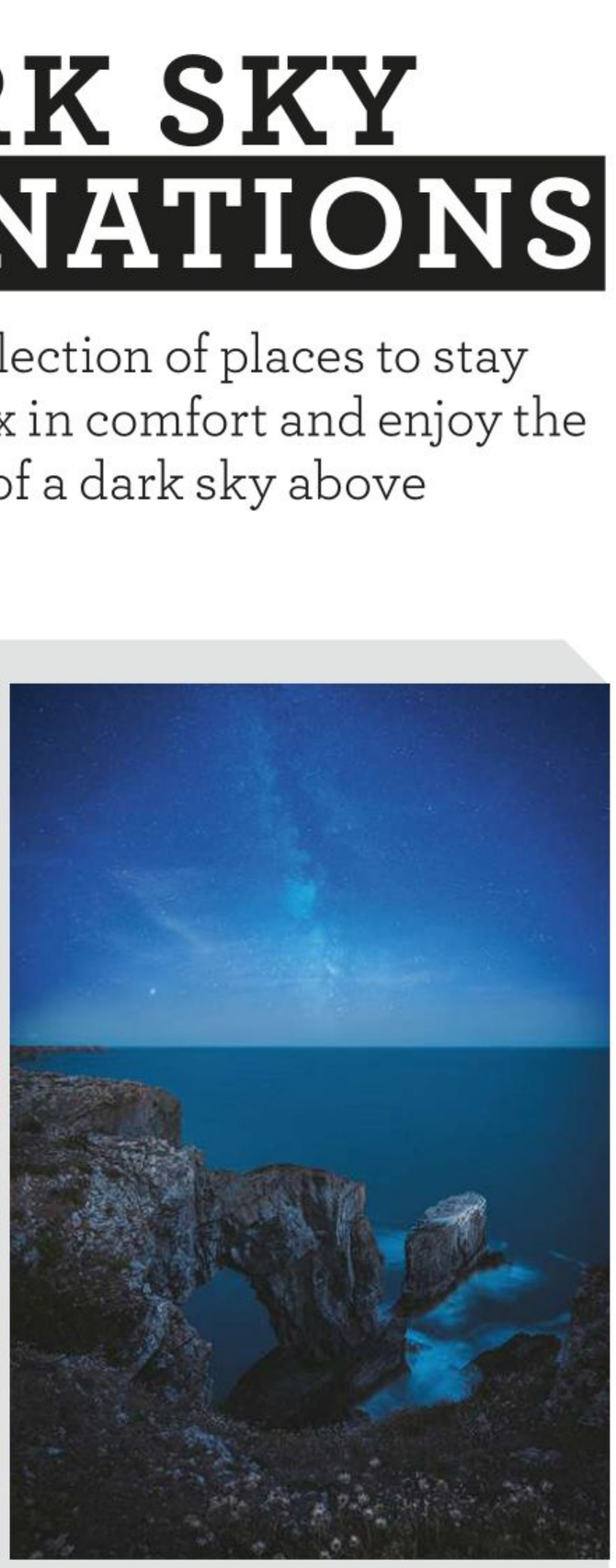


WILL GATER X 2, MATT STANSFIELD/ISTOCK/GETTY IMAGES, KEITH MORRIS/ALAMY STOCK PHOTO, SIMON ROBERTSON/ISTOCK/GETTY IMAGES, CHART BY PETE LAWRENCE

DARK SKY DESTINATIONS

Here's a great selection of places to stay where you can relax in comfort and enjoy the experience of a dark sky above





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Reach for the stars: a star party in full swing in Bükk National Park, Hungary

Stargazing in EASTERN EUROPE

Astronomers and astrophotographers are discovering a growing dark-sky scene in Europe's eastern reaches, as Jamie Carter reveals

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Pristine night skies are becoming harder to find. In fact, 2016's *New World Atlas of Artifical Night Sky Brightness* revealed that 60 per cent of Europeans cannot see the Milky Way and that 99 per cent live with at least some light pollution. If asked to name the best places to go stargazing in Europe, most people's thoughts might lead them to mid-Wales, Iceland and the Canary Islands, all on the western edge of the continent. But, as we know that much of western Europe is blighted by light pollution, have you ever considered a stargazing trip to eastern Europe?

There is no consistent definition of the precise area covered by the term 'eastern Europe', but it generally includes the likes of Poland, the Czech Republic, Slovakia, Hungary and Croatia, all of which have fewer cities and large rural areas, including many huge national parks. Several of these are now establishing themselves as 'dark sky' parks with a growing reputation for stargazing and astronomy.

Some, like Hortobágy, Zselic and Bükk in Hungary, are International Dark Sky Parks certified by the International Dark-Sky Association (IDA). Others

▲ Dark encounters: Croatia's Petrova gora-Biljeg is home to a crumbling war monument that's become a mecca for astronomers and astrophotographers

▲ Star trails are captured from Zselic Starry Sky Park in Hungary. It was awarded IDA status in 2009

Have gear, will travel

Knowing what kit to take with you can make or break a good astronomy trip abroad

Whether your primary aim is stargazing, astronomy, astrophotography or nightscape photography, it will determine what gear you need to take to eastern Europe. If observing is your main aim, consider taking only binoculars. Used under dark sky, a pair of 10x50 bins will reward you with unforgettable sights, and if you're headed to a star party or an observatory, there may be no need to take your own scope.

However, if deep-sky observing or astrophotography is your thing, go for a 'travel scope' that's small, lightweight and easy to set up. Consider a refractor, which is smaller and hardier than a reflector, or a compact Schmidt-Cassegrain or Maksutov-Cassegrain.

A spotting scope is another option; they're compact, weatherproof and mount on a camera tripod. Large tripods should be placed in check-in luggage. Don't forget the mounts, counter-weights and eyepieces for your scope, spare batteries and a red flashlight. Remember too the most important accessories for a stargazing trip to eastern Europe: extra layers, gloves and a flask.

▲ Night and day: 10x50 binoculars are an ideal travelling companion

1 Izera Dark-Sky Park, Czech Republic & Poland

2 Beskydy Dark-Sky Park, Czech Rep., Slovakia & Poland

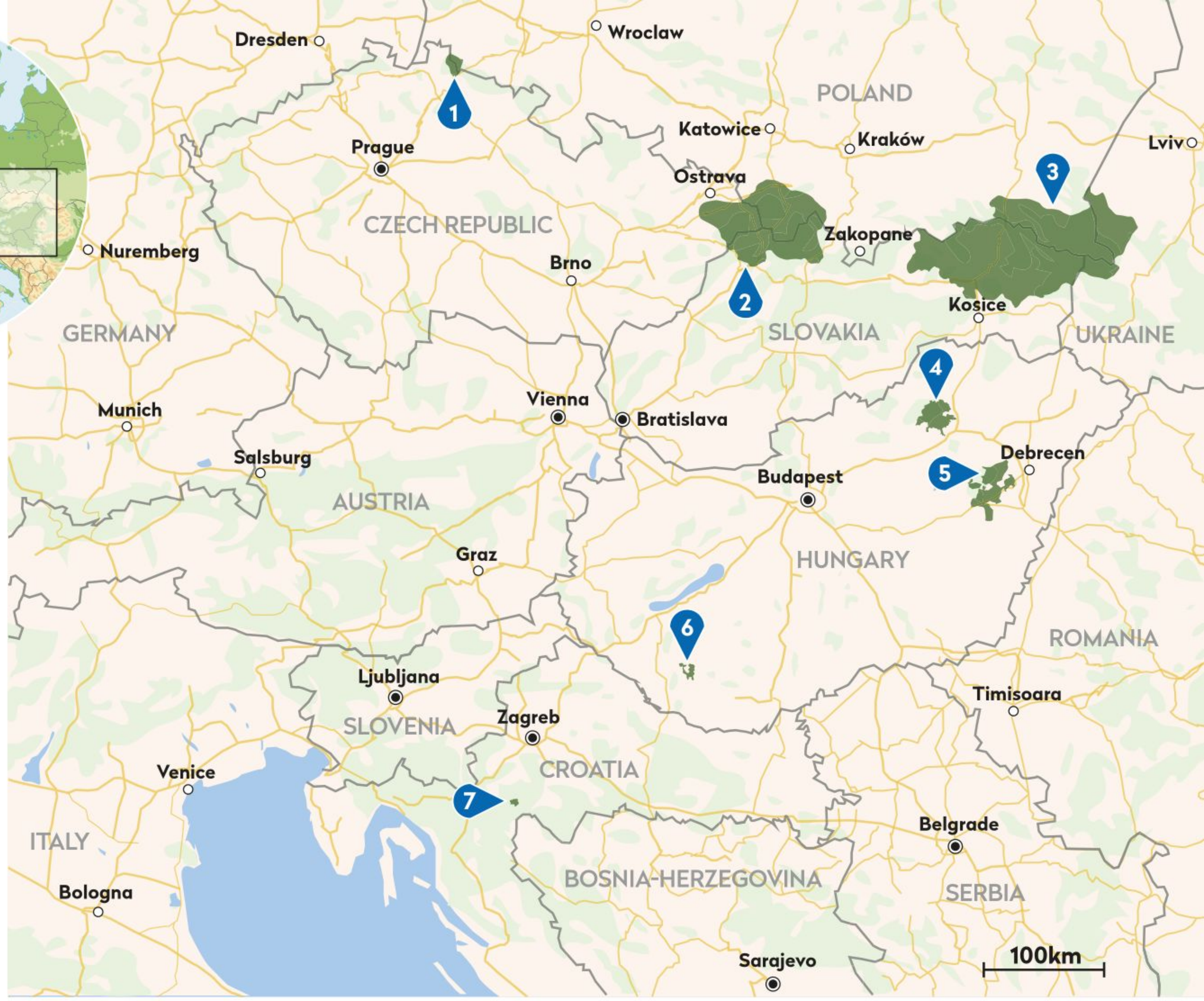
3 East Carpathian Dark-Sky Tripark, Slovakia, Poland & Ukraine

4 Bükk National Park, Hungary

5 Hortobágy National Park, Hungary

6 Zselic National Landscape Protection Area, Hungary

7 Petrova gora-Biljeg, Croatia



▲ A map of eastern Europe's spectacular dark-sky locations, including certified Dark Sky Parks at Bükk (4) Hortobágy (5) and Zselic (6), and one of the world's largest dark-sky areas, the East Carpathian Dark-Sky Tripark (3)

The Milky Way is revealed in all its glory above Hungary's Hortobágy National Park

have no official designation but use names such as 'starry sky park'.

Many owe their existence, or at least their designation, to local astronomers from nearby cities in search of darkness. "We've always travelled from Zagreb, Croatia's capital, to find dark-sky locations to enjoy astronomy," says Boris Štromar, president of Croatia's Beskraj (meaning 'infinity') Astronomy Society. "We started organising annual star parties for amateur astronomers in 1999 and the event became very popular. But the skies at the location soon deteriorated because of the rising light pollution."

Chasing the dark

It was then that Štromar discovered Petrova gora-Biljeg, about an hour's drive from Zagreb. It's now an iconic place to visit for astrophotographers thanks to its bizarre-looking war monument. "We realised that if we don't make an effort to protect the night sky, we will just keep being pushed farther and farther away, and our children will not have the ability to see the Milky Way anymore," says Štromar.

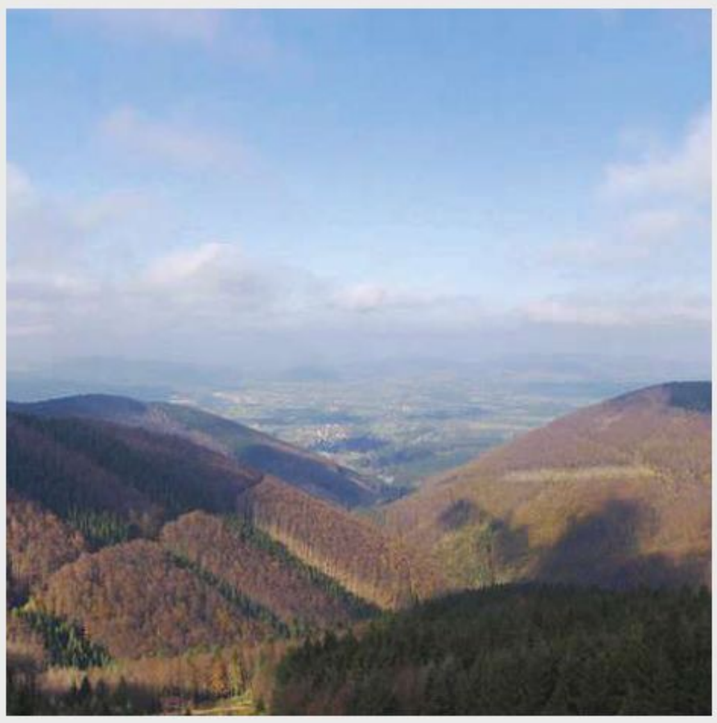
Rapid economic development in eastern Europe has worsened light pollution in the last 15 years, with some areas of Poland now as bright as some of Europe's top industrial regions such as the Netherlands, Belgium and northern Italy. That situation has sparked a dark-skies movement committed to reducing light pollution in areas that still have dark skies. One of its successes has been Zselic Starry Sky Park in Hungary's Zselic National Landscape Protection Area. ▸

Pick of the best dark sites

Seven eastern Europe locations that are renowned for their dark skies

HORTOBÁGY NATIONAL PARK, HUNGARY

A UNESCO World Heritage site and Biosphere Reserve as well as an International Dark Sky Park since 2011, the 82,000 hectare Hortobágy National Park in eastern Hungary has an observatory with a 140mm apochromatic lens telescope. "We organise star walks and observatory programmes for the public," says István Gyarmathy, Hortobágy's dark-sky park coordinator.



BESKYDY DARK-SKY PARK, CZECH REPUBLIC, SLOVAKIA & POLAND

The region of eastern Czech Republic that borders Slovakia, the Beskydy Protected Landscape Area, is mostly mountains covered in indigenous primeval forests. It's possible to take part in various stargazing activities in the mountainous setting of Gruň, including a 'relaxation under the stars' sky tour. There is ski-style accommodation available.

BÜKK NATIONAL PARK, HUNGARY

This vast International Dark Sky Park in the Bükk Mountains of northern Hungary hosts a landscape littered with thousands of caves and hiking trails. "In a couple of years we will open an astronomical visitor centre in our national park, near the village of Répáshuta," says Richárd Novák at Bükk National Park, who helped set up the Star Park two years ago.

ZSELIC NATIONAL LANDSCAPE PROTECTION AREA, HUNGARY

Zselic Starry Sky Park in southwest Hungary has been an International Dark Sky Park since 2009. "There are star-watching walks organised by the visitor centre and there have been astronomy camps in the vicinity," says Zoltán Kolláth, Zselic Starry Sky Park coordinator.

IZERA DARK-SKY PARK, CZECH REPUBLIC & POLAND

Established a decade ago in both the Czech Republic and Poland, the Izera Dark-Sky Park is a project of the Astronomical Institute CAS (Czech Republic) and the Astronomical Institute UWR (Poland). Star parties – including lectures and telescope observations – are held in spring and autumn.

EAST CARPATHIAN DARK-SKY TRIPARK, SLOVAKIA, POLAND & UKRAINE

How about a 'dark sky corridor' that covers three different countries? This tripark is one of the largest dark-sky areas in the world. In Poland's Lutowiska, Brzegi Górne and Stuposiany there are viewing terraces, while the latter's information centre has scopes and a mini observatory.

PETROVA GORA-BILJEG, CROATIA

Established in June 2019, this dark-sky location in Croatia is home to the iconic Petrova gora-Biljeg, a ruined stainless steel World War II monument which is ideal for nightscape photographers and observers. A star party is held on the plateau beneath the monument at New Moon each year in September.

Party pieces: a stunning Perseid meteor display in the skies above Croatia's Petrova gora-Biljeg

Try to coincide your trip with a star party or a scheduled night sky tour. That will likely mean that you arrive at New Moon

▸ "The initial success of the park helped the other two locations – Hortobágy National Park and Bükk National Park – to start their dark-sky programmes," says Professor Zoltán Kolláth, coordinator at Zselic Starry Sky Park and the man who started the dark-sky park programme in Hungary. All three are now accredited International Dark Sky Parks and host star-watching walks, while Zselic has a visitor centre and public observatory with a digital planetarium and various exhibits. Better still, Kolláth's university in Budapest (Eötvös Loránd) won a grant that's helping fund a new lighting system in two villages, one in Zselic and one in Bükk. "We finished the remodelling at the end of 2018 and now there is a system with minimal light pollution that has good lighting for the citizens," says Kolláth.

That's impressive progress, but in Croatia there's even a new 'dark-sky law' coming into force soon that's unlike any other in Europe. It essentially limits all public lighting and bans the use of light beams, while in protected areas the limits are much tighter. "It makes all the protected areas in the country – 12 per cent of the total land area – compatible with International Dark-Sky Assocation requests for ecological lighting," says Štromar.

Its credentials assured, how should you plan a trip to check out the dark skies of eastern Europe? First, do your research. Try to coincide your trip with a star party or a scheduled night-sky tour. That will likely mean that you arrive at New Moon, which you should aim for regardless to catch the darkest skies. Google Maps can help you scout specific observing locations, but take local advice and visit the site before darkness descends (**www.lightpollutionmap.info** and **darksitefinder.com** are also helpful). Take a flight to Prague, Budapest, Krakow or Zagreb, rent a car, and go and explore one of Europe's newest and most intriguing dark-sky settings.

Jamie Carter is a well-travelled amateur astronomer and author of *A Stargazing Program for Beginners: A Pocket Field Guide*

The fundamentals of astronomy for beginners

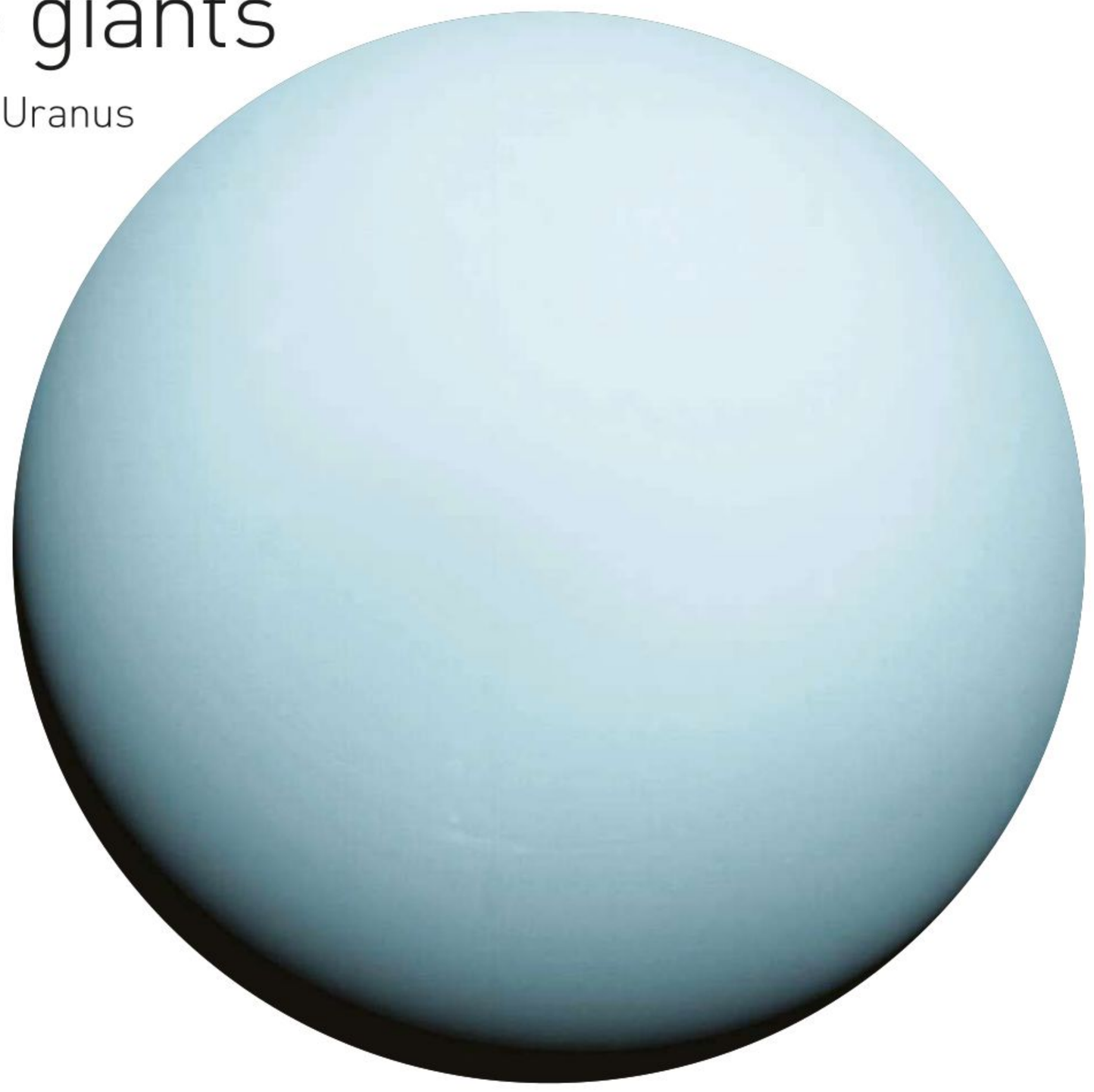
EXPLAINER

Exploring the ice giants

How the space probe Voyager 2 made Uranus and Neptune a little less mysterious

Deep in the largely unexplored realms of the outer Solar System – beyond the gas giants, Saturn and Jupiter – lurk the two ice giants: Uranus and Neptune. These four planets formed 4.6 billion years ago from a cloud of gas and dust known as the solar nebula. The material closest to the Sun gathered and condensed into the four rocky terrestrial planets while leftover 'lighter' elements, like hydrogen and helium, swept outward and became the four giants.

In these distant icy realms, a game of cosmic billiards ensued. The giants migrated inward and outward, scattering some objects and kicking out others. It's thought that Uranus and Neptune, once closer to the Sun, traded places in the process of migrating beyond the 'snow line', where gas is cold enough to become ice. Finally, at 19AU and 30AU (where 1AU is the distance between Earth and the Sun), Uranus and Neptune settled into their current 84- and 165-year orbits to become the ice giants we recognise today.



NASA/JPL-CALTECH/ NASA/JPL/USGS/ LAWRENCE SROMOVSKY, UNIVERSITY OF WISCONSIN-MADISON/W.W. KECK OBSERVATORY

▲ **First close up: Uranus as seen by Voyager 2, which came within 81,500km of the planet in 1986**

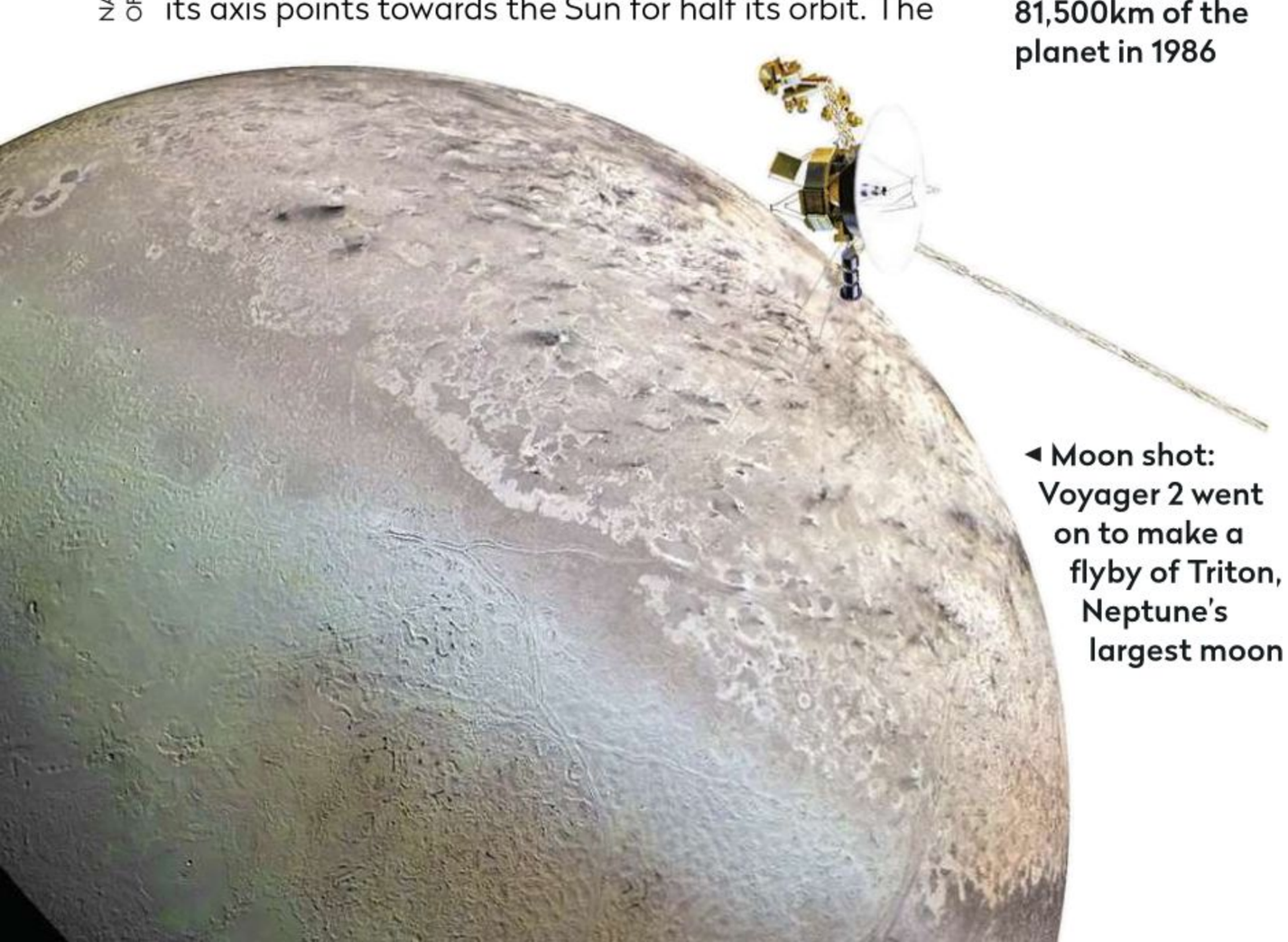
Voyage to the coldest planet

Uranus is the victim of a planetary collision: it is tipped over by 98° and rolls along on its side so that its axis points towards the Sun for half its orbit. The result is that both poles are bathed for decades in continuous sunlight or darkness during its long seasons. Despite not being the farthest planet from the Sun, Uranus is the coldest in the Solar System.

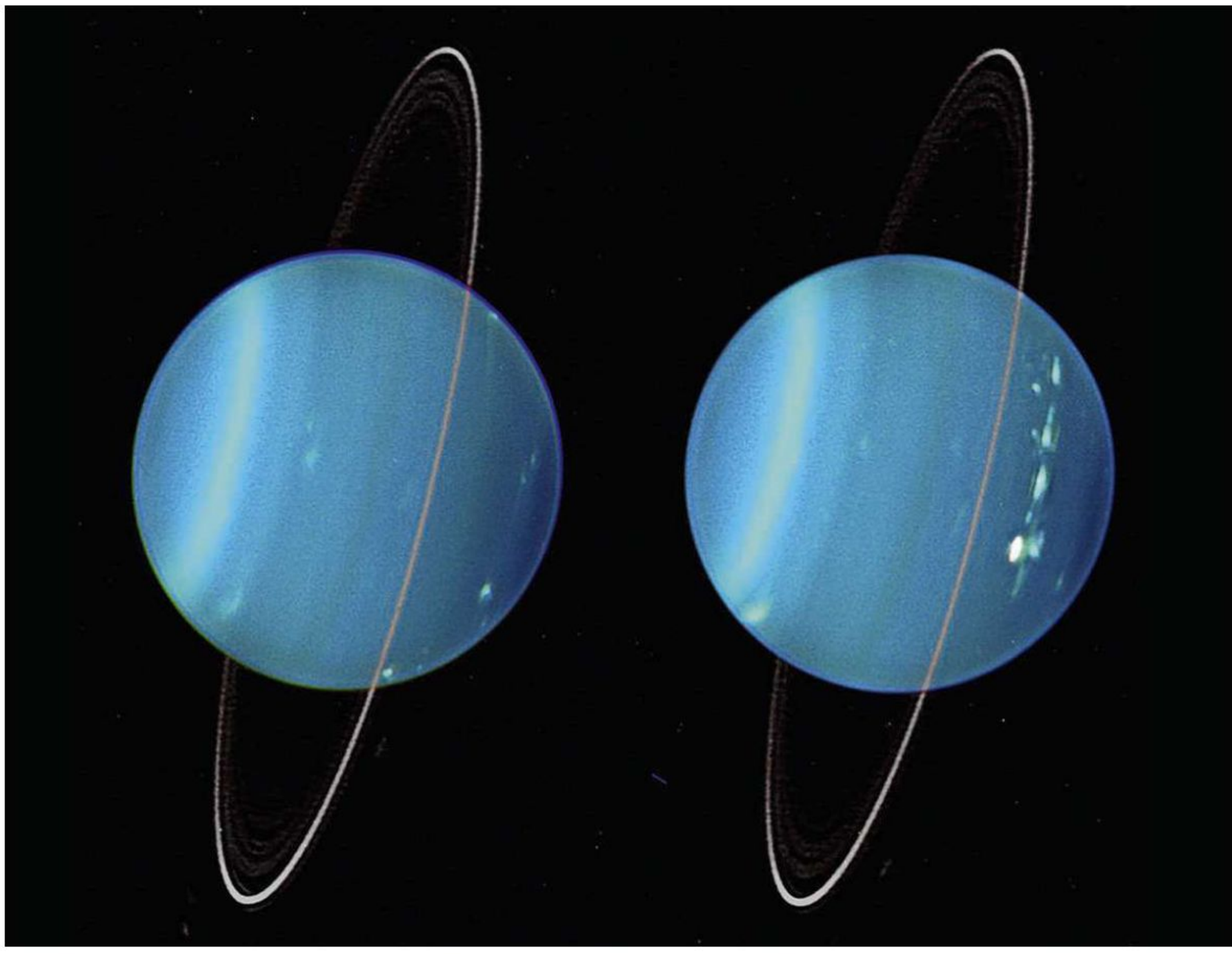
In 1986, NASA's probe Voyager 2 briefly flew past Uranus, getting closer than any spacecraft before or since. The photographs sent back initially showed that Uranus was disappointingly bland, with barely any features in its gaseous blue-green atmosphere.

Now, we know the planet is anything but boring. It is mostly composed of water ice, hydrogen, helium and methane, enveloping an Earth-sized rocky core surrounded by a dense fluid of icy materials. Since the Voyager 2 flyby, ground-based telescopes and images from the Hubble Space Telescope have revealed fleeting ice-crystal clouds, giant storms, diamond rain and wind speeds reaching up to 1,450km/h.

The planet has 27 known moons, nearly all named for Shakespearean characters, and is encircled by



◀ **Moon shot: Voyager 2 went on to make a flyby of Triton, Neptune's largest moon**



13 icy rings filled with faint dust and golf ball-sized chunks of rock. The rings on the inside are thin and dark, while those at the outer edges are brightly coloured.

Like with Uranus, Voyager 2 is the only spacecraft to have flown past Neptune, and the visit in 1989 was a revelation. Both planets are four times the size of Earth and share a similar composition, but where the inner planet appeared placid, Neptune's blue atmosphere was ablaze with bright clouds and storms. Among them was the anticyclonic Great Dark Spot (GDS). While this has now disappeared, in the suspected 1,000km deep 'weather layer' migratory storms have erupted and a similarly sized new GDS is currently emerging, surrounded by winds in excess of 1,609km/h.

Need for new missions

The rings of Neptune are unlike those of other planets as they are faint, incomplete clumps or arcs of carbon-coated dust and ice, perhaps shepherded by its small moon, Galatea. Neptune has 14 known moons, the largest being Triton with a diameter of 2,700km. It circles the ice giant in the opposite, or retrograde, direction, and is possibly a dwarf planet captured from the frozen reservoir of objects forming the Kuiper Belt.

Scientists were wowed by the moon's nearly craterless, crack-ridden crust and the geyser-like jets of nitrogen ice blasting spaceward from its south pole, thousands of kilometres high. It is now thought that Triton may be hiding an ocean that could be a possible habitat for some form of life.

With just Voyager 2's visits so far, new missions to the ice giants are needed. These could capture the shifting seasons and changes in light at the poles, plunge probes into the atmospheres, and send robots to 'sniff' and sample moons. Perhaps a spacecraft could explore while transiting to the Kuiper Belt and beyond. For now, these remain engineering concepts, but who knows where such concepts could lead.

▲ Two images taken by Hawaii's WM Keck Observatory reveal Uranus tilted on its side and its faint ring system. The lower part of the right-hand image shows the storms in the planet's atmosphere.

Jane Green is a fellow of the Royal Astronomical Society and author of the Haynes *Astronomy Manual*

How to observe the ICE GIANTS

A little optical help is needed to find the farthest planets in the Solar System

Both the ice giants are well placed in the sky this October, and on the 28th October, Uranus will reach opposition – its closest approach to Earth when it is exactly opposite the Sun.

With a dark sky and good eyesight, it might just be possible to make out Uranus with the naked eye. It will appear like a point of light on the sky. Finding Neptune, however, will require a set of binoculars. You can find out where both the ice giants are by looking at The Planets section of the Sky Guide on page 48.

To make out the disc of either planet, you'll need a telescope. Uranus should begin to become clear with an aperture of at least 3 to 4 inches and a magnification of 100x to 150x. As Neptune is far more distant, its disc appears smaller in the sky, meaning you'll require a larger telescope – at least 6 inches in aperture with a 200x magnification. At these high magnifications, your observations may be affected by seeing, where the turbulence in the atmosphere causes the image to shimmer. Experiment with different eyepieces, Barlow lenses and focal extenders to find the best magnification on any given night.

Practical astronomy projects for every level of expertise

DIY ASTRONOMY

Make a time-lapse video

Our guide to capturing the motion of the night sky in an atmospheric video

This month's project is to make a video of the night sky that demonstrates the rotation of Earth. While we observe the stars rising in the east and setting in the west, this motion is not the stars themselves moving, but Earth spinning on its axis. In the Northern Hemisphere, the axis of rotation is pointing towards the star Polaris, in Ursa Minor, and therefore all the other stars appear to be rotating around it. Astrophotographers can show this effect with long-exposure photographs of the night sky, which show the trails of the stars as they circle Polaris. Such pictures of star trails can be stunning, but there is another, more engaging way to show this motion: a time-lapse video.

The basic purpose of a time-lapse is to show the change that happens during a timescale we are not usually aware of, or can only perceive at widely spaced intervals. This change could be the development of storm clouds, a plant growing or, for the purposes of this project, the apparent movement of the stars.

To create the video, we are going to take a series of images of the night sky separated by a certain period of time, called the interval. Each image taken will represent a single frame of the final video. The standard playback speed of a video is 25 frames per second, which means the interval is 1/25th of a second. We'll still be using the rate of 25 frames per second for our video, but the difference will be that each shot will be separated by a greater interval. Furthermore, as we are capturing the night sky, each shot will have an exposure of several seconds. The duration of our time-lapse will therefore be determined by how many shots we can take. For example, taking 250 shots at 25 frames per second will make 10 seconds of video.

We'll need to know how long to leave our camera running to produce the length of video we want. For this, we need to know the interval, which is made up of two things: the exposure time (how long the camera's shutter remains open) and the buffer time (how long it takes to write the resulting shot to the camera's memory card). A sufficient amount of time should be allowed between shots for the camera to finish writing the picture to the card. The sum of these two values gives us the interval between shots. We can now calculate the duration of our time-lapse shoot with the formula:

Interval x frame rate x time-lapse video duration = shooting time needed.

So, if our camera settings result in an interval of 25 seconds and we want a 10-second time-lapse video, the total shoot time will be 104 minutes (25x25x10 = 6,250 seconds, or just over 104 minutes).

By following this guide, you too should be able to create an atmospheric time-lapse video showing the motion of the night sky.

Tools and materials

- A DSLR camera with a wide-angle lens; any lens with a focal length of at least 24mm should be fine.
- An intervalometer, either built into the camera or that plugs into it.
- A sturdy tripod with a ball head attachment. A bubble level is also useful to achieve a level shot.
- A high-speed, high-capacity memory card.
- A reliable power supply for the camera, either mains power or a battery grip that holds two batteries at once.
- Video-editing software, such as Adobe Premier Elements or Windows Movie Maker.

Steve Brown is an astronomer, astrophotographer and writer based in Stokesley, North Yorkshire

For star trails, better to use long-exposure photographs than time-lapse video

ALL PICTURES: STEVE BROWN

Step by step

Step 1

Choose a suitable location. This should have a relatively unobstructed view of the sky, although foreground objects can add interest. Standing stones are a bonus. Try to ensure the scene won't be interrupted by artificial lights during the shoot.

Step 2

Assemble your tripod, camera and intervalometer. The camera should be level with the horizon or your choice of foreground objects. The whole setup should be as sturdy as possible – any movement of the camera during the shoot can spoil the video.

Step 3

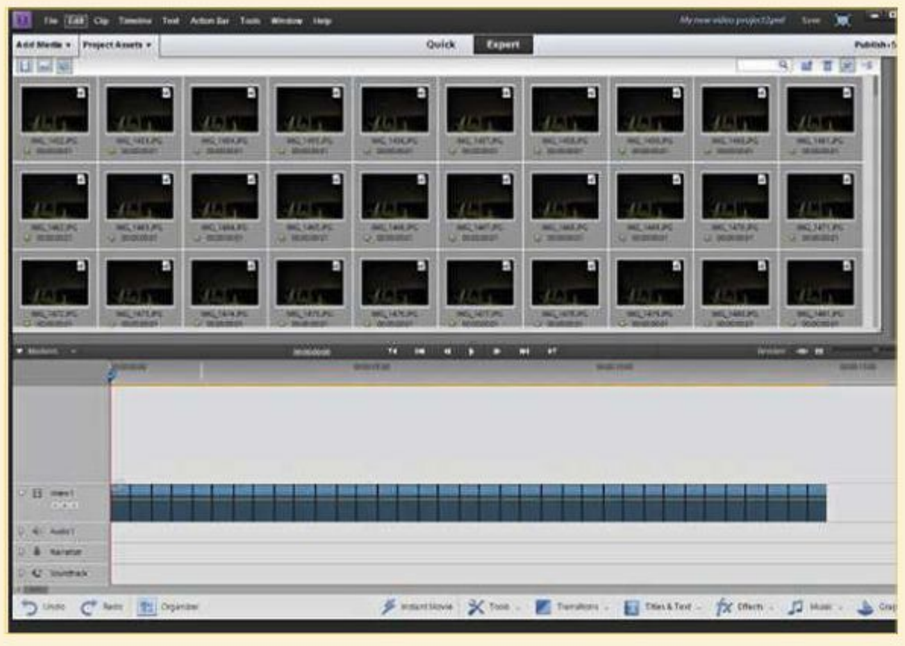
Take a series of test shots to establish good composition. You should aim to have as much sky as possible in your shot, while keeping foreground objects in view. Be aware of any bright stars or planets that will move into or out of the frame.

Step 4

Focus the camera on the stars and leave the lens in manual focus mode. Take some test shots at different exposure settings to make sure the stars don't trail. Set your intervalometer to take unlimited pictures at your calculated time interval.

Step 5

Leave the camera running for the duration of the time-lapse. Do not move the camera or walk into the frame while it is taking pictures, unless you want to be featured in the video. Use a light source to illuminate any foreground objects.



Step 6

Import the files to your chosen video editing software. Drag these to the video timeline, ensure that 'Still image default duration' is set to one frame, and export the files as a 25 frame per second video. Finally, enjoy your night sky time-lapse.

Take the perfect astrophoto with our step-by-step guide

ASTROPHOTOGRAPHY CAPTURE

Imaging the moons of Uranus

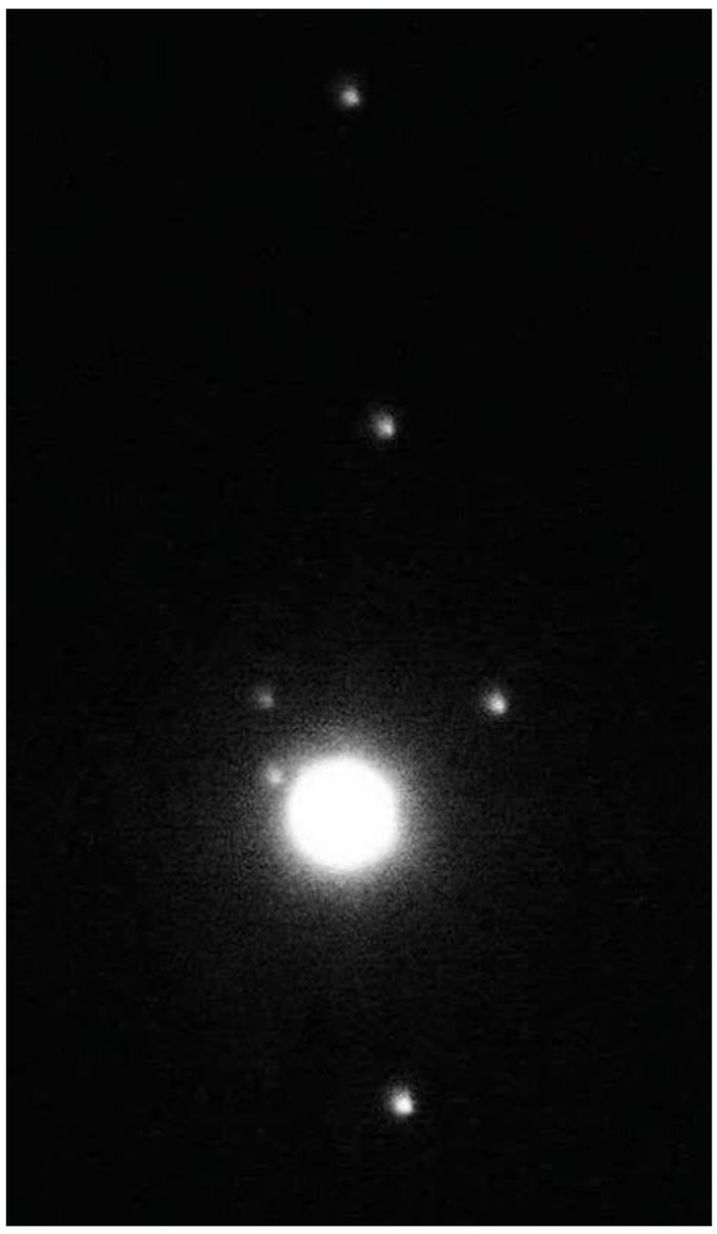
How to make the most of Uranus's position by looking out for its five major moons

With a certain degree of irony, Uranus is currently the best positioned planet from the UK. The irony arises from the fact that telescopically, the planet doesn't give much away. A large telescope and good seeing are required to reveal any disc features at all, and these typically manifest only as weak bands encircling Uranus's globe.

Yet there is a feature of the Uranian system that poses a compelling challenge for imagers: the five brighter moons. These are, in increasing distance from their host planet, Miranda, Ariel, Umbriel, Titania and Oberon. Their apparent magnitudes range from +13.7 for Titania to +16.0 for Miranda, which puts them well within range of many imaging setups. The proximity of the inner moons, Miranda and Ariel, to Uranus does make them more difficult, so the best advice would be to concentrate on the outer three and regard a positive capture of those two as a bonus.

The moons orbit close to Uranus's equatorial plane and as the planet appears tilted from Earth, this means that each moon orbit describes a fairly wide ellipse. The consequence is, unlike the case with Jupiter and Saturn, the Uranian moons do not currently appear to interact with their host, but appear separated by a small amount. This makes them ideal imaging targets because they are always guaranteed to be 'somewhere' in the shot as long as you are centred on Uranus and have a wide enough camera field to include them.

Actually, the reality is a bit trickier than this. You'll need to up the sensitivity of your camera in order to capture the moons, but at the same time try to avoid overexposing Uranus – something which is quite easy to do.



▲ Be aware when imaging Uranus of the inner moons being lost in the planet's glare

Pete Lawrence is an expert astro imager and a presenter on *The Sky at Night*

Another issue is going to be moisture. During a long October night in the UK, it's likely there is a strong chance of some dew in the atmosphere. This may lead to misting on telescope optics, which, in turn, causes the light to spread in an image. With Miranda and Ariel being close to Uranus, this could mean their faint dots become lost in the planet's apparent glare. It is therefore essential to check all optical surfaces constantly. If moisture does build up, the best way to remove it is by gently blowing warm air over the affected surfaces using a 12V camping hair dryer.

The outer moons – Umbriel, Titania and Oberon – are largely immune to such effects. Their distances from Uranus are sufficient to keep them out of the central light-scatter zone.

Depending on your setup, expect to set your gain reasonably high and to take exposures of several seconds to record the moons. For this reason, a tracking mount would be beneficial. Seeing is another major issue because under unstable conditions the moons will appear to dance around, smearing their delicate light over a much larger area than normal. Under such circumstances, the moons will simply appear dim and poorly focused.

With Uranus being so well presented, this is a golden opportunity to acquaint yourself with one of the Solar System's outer planets and at least some of its extensive family of moons.

Recommended equipment: a 200mm or larger telescope, an optical amplifier (Barlow or Powermate), a monochrome or infrared camera and an infrared pass filter

✉ Send your images to:
gallery@skyatnightmagazine.com

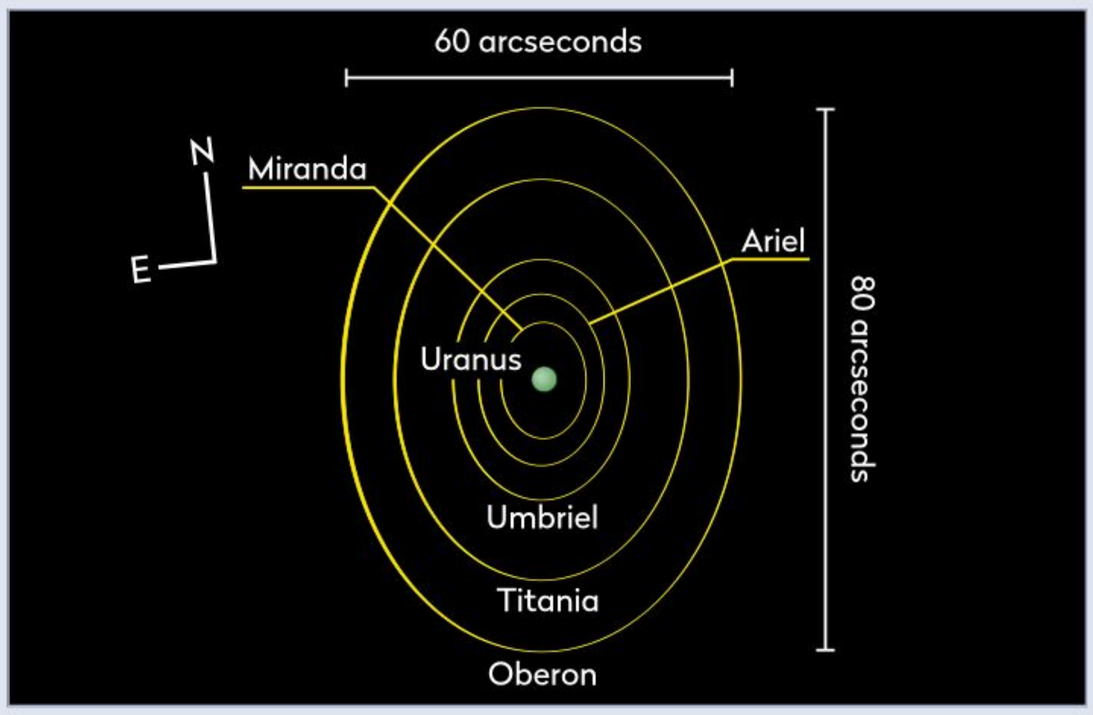
ALL PICTURES: PETE LAWRENCE

STEP 1

The best kit for imaging Uranus and its moons is a high frame rate camera with extended exposure capability. A 200–250mm scope is recommended, but smaller apertures may well succeed with good seeing. A Barlow or Powermate is essential to allow you to up the effective focal length and increase image scale.

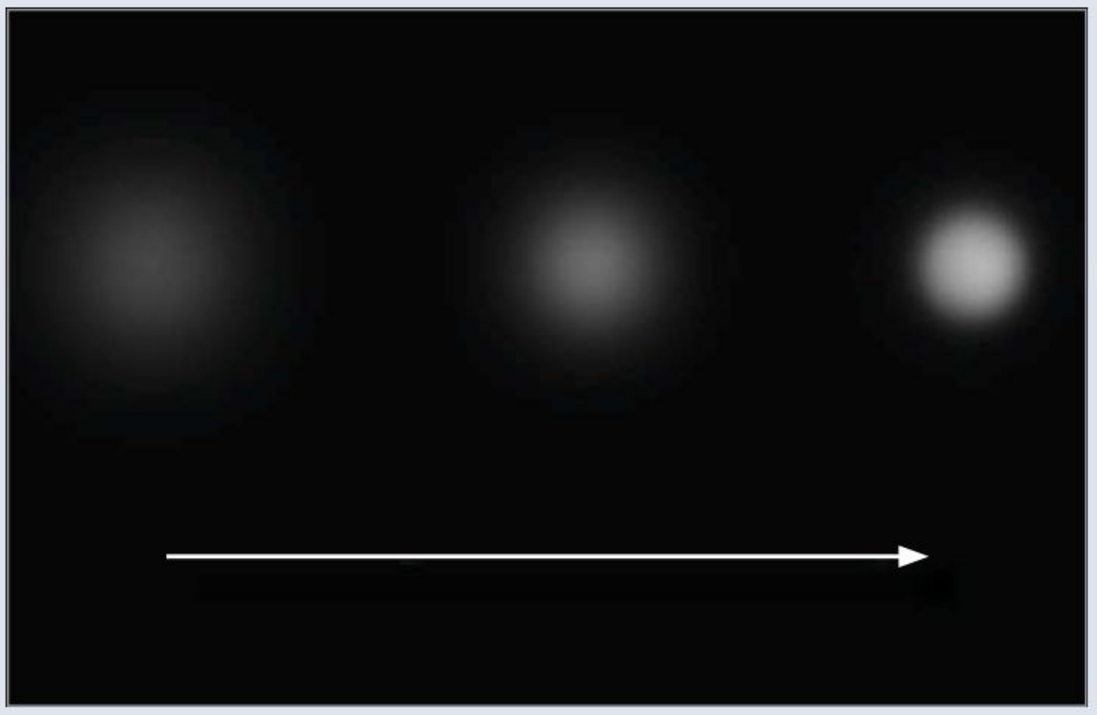
STEP 2

Uranus is just visible with the naked eye, but be aware that it is currently in a barren area of sky devoid of nearby navigational bright stars. Turn to page 48 if you need any help finding it. Monochrome or sensitive colour cameras with infrared capability are recommended along with the use of an infrared pass filter.



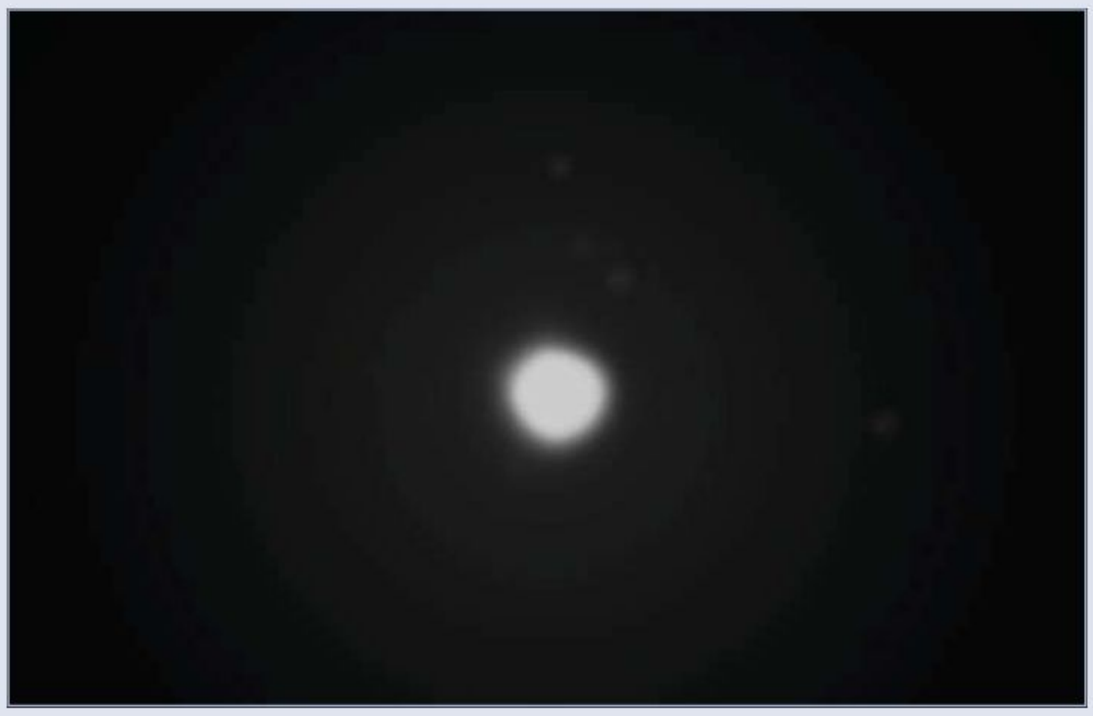
STEP 3

In order to record the moons, your image scale will need to give you a field of view at least 2 arcminutes across on the camera's chip. The focal length needed to achieve this is given by the formula: f (mm) = 3,438 x D (mm) / FoV (arcmin), where D is the diagonal size of the camera chip being used.



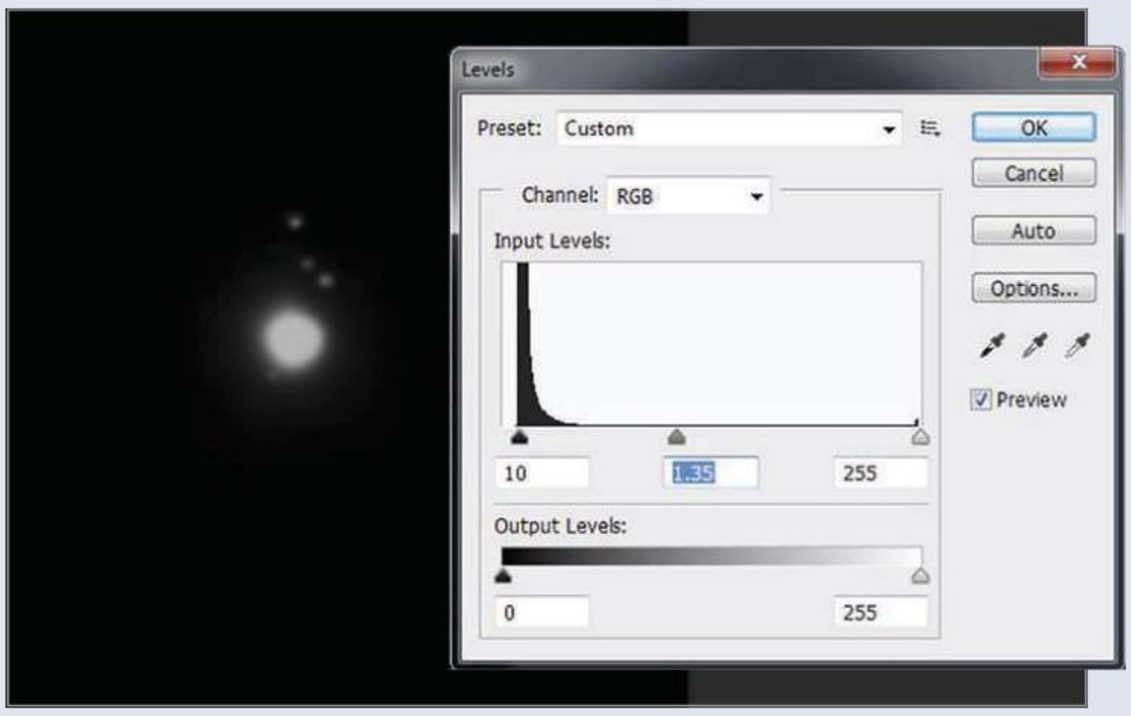
STEP 4

With everything set up, centre Uranus on the camera chip, adjust exposure to give a reasonably high frame rate, and focus on the planet. Take your time – accurate focus can make or break the image. Once done, adjust gain to 50 per cent and the exposure time to between 0.5 and 5 seconds. Uranus will become overexposed.



STEP 5

You should ideally be able to see some of the moons with the settings described. If not, consider upping the gain to around 70 to 80 per cent. If your capture software permits, consider taking a dark frame to reduce image noise. Once the moons are visible, aim to capture between 20 and 200 image frames.



STEP 6

Process the capture file using registration-stacking software, such as RegiStax or AutoStakkert!. When the final 'distilled' image has been produced, load into an image editor and adjust using the curves or levels tools to make the moons stand out. Miranda may take a bit of effort to extract from the glare of Uranus.

Expert processing tips to enhance your astrophotos

ASTROPHOTOGRAPHY PROCESSING

Using ICE to create a Milky Way mosaic

How the free and user-friendly software helps stitch your images together seamlessly

▲ **A selection of overlapping photographs of the Milky Way, ready to be turned into a single image**

For astronomers and non-astronomers alike, one of the most awe-inspiring sights has to be the Milky Way arching across the night sky. As it covers such a large area, though, capturing it entirely in one photograph can be difficult, even with a wide-angle lens. But a series of overlapping photographs can be stitched together into a mosaic to create a single image. This can be done using a free piece of software called Microsoft Image Composite Editor (ICE), which is simple to use and helps you create striking images.

Ideally, you should be photographing the Milky Way from a dark-sky location, where there is little light pollution and no interference from moonlight. The best time of year to capture the full arc is when the Milky Way sits a bit lower in the sky during autumn in late evening or spring in the early hours. But nothing stops you imaging the Milky Way at other times of the year if the skies permit.

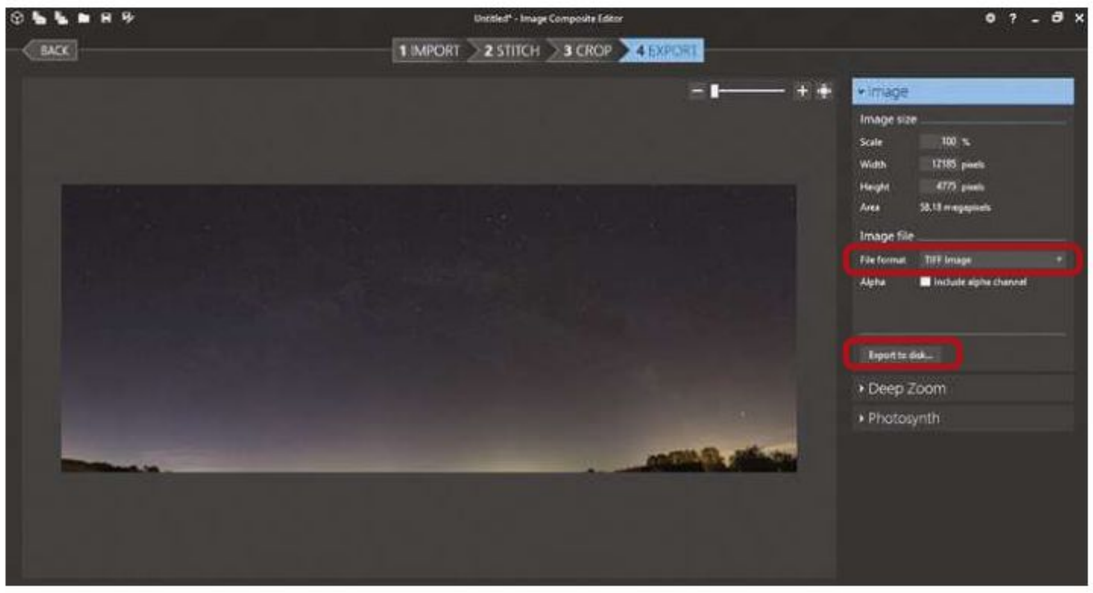
For this project, a series of 22 overlapping photographs (a small selection of which can be seen above) were taken in two horizontal rows in the early hours during May 2019 in north Oxfordshire. They were taken under Bortle Class 4 skies – where Class 1 represents perfectly dark skies and Class 9 is for brightly lit inner-city skies. The camera used was a Canon EOS 1100D with an 18–55mm lens at a focal length of 18mm. Each image was a single shot – ISO 1600 for 20 seconds at f/3.5 – with the camera in portrait orientation. They were all shot in RAW mode. The distortion created by a camera lens can make it difficult to stitch images together, so each of the starting images had a lens correction applied in Adobe Lightroom, then they were exported as TIFF files. Aside from a lens correction, the photographs should be unprocessed: processing may introduce artefacts that will affect the ability of the software to stitch them together.

The first thing to do in Microsoft ICE is to click on 'New Panorama From Images' and then select all of

▼ **Once the photographs have been imported into ICE, the stitching process can begin**

ALL PICTURES: MARTIN LEWIS

▲ **Try out the different projection options on your mosaic – such as 'Spherical' or 'Fisheye' – to see which one works best**



▲ **When you're ready to export your cropped image, keep the scale at 100 per cent and make sure to save in TIFF format**

the photographs you want to stitch together. The software is good at detecting the structure of your mosaic, but check that the drop-down menu on the right-hand side is set to 'Simple Panorama' and that 'Autodetect' has been selected.

At the top of the page are four tabs. The photographs will begin in 'Import' and when you move on to 'Stitch', the software will automatically begin to align and stitch all of them together into a single image. Once completed, this mosaic will appear overlaid with a grid. On the right at this stage is a list of different projection effects that can be applied. The ICE program will have picked a default one, but experiment until you find the projection that works best for your mosiac. In this instance, the 'Spherical' option gave the most aesthetically pleasing yet realistic result.

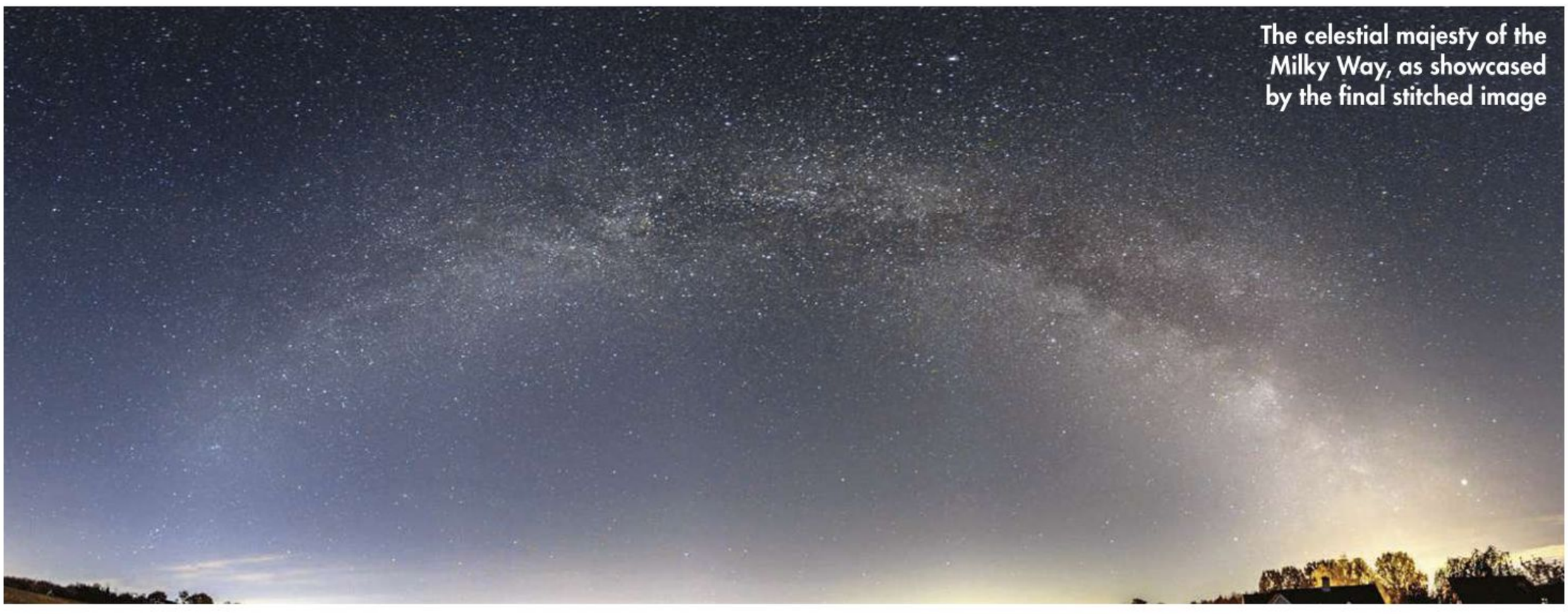
A sense of perspective

The grid over the mosaic will assist with changing the perspective, which can be done by clicking and dragging on different areas of the image. You may want to begin by placing the centre of the Milky Way arc at the centre of the image. Dragging up and down or side to side can alter the angle of the arc or tilt the image so that you can make sure that it is perfectly aligned with the horizon. Experiment until you are happy with how it is looking. The top edges will become totally distorted during the process of making these changes, but don't worry as this can be fixed in the next step.

This comes when you move on to 'Crop', the third tab at the top. Click and move the edges of the box that appears over your mosaic to crop the area of the image you want to keep. Once that is done, move on to the final tab, 'Export'. You will see on the right-hand side a section called 'Image size'. The default setting on Microsoft ICE will set the 'Scale' to 100 per cent – as this is still an unprocessed image, it is important that you keep this full size or data will be lost. Under this is a drop-down menu called 'File format'. Select 'TIFF' because, at this stage, you will want to avoid JPEG compression.

Finally, click 'Export to Disc' and save the image where you would like it. You can now process your stitched mosaic using your preferred software to further bring out the Milky Way in more detail, as shown in our final processed image.

Mary McIntyre is an astronomer and dedicated astro imager based in Oxfordshire



The celestial majesty of the Milky Way, as showcased by the final stitched image

Your best photos submitted to the magazine this month

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PHOTO OF THE MONTH

△ The Veil Nebula

Kfir Simon, Tivoli Astrofarm, Namibia, 1–5 June 2019

Kfir says: "I wanted to capture the outer shell of the Western Veil Nebula. I used an exposure of four hours with an Ha (hydrogen-alpha) filter and used it twice: first as luminance and second as the red channel. This allowed the extremely dim nebula wisps to be strongly visible in red. The outcome was better than I imagined, thanks to Namibia's dark skies."

Equipment: Apogee Alta U16M camera, 16-inch Dream Astrograph
Exposure: 4h Ha, 1h OIII, 1h SII, 20' each RGB
Software: Photoshop

Kfir's top tips: "When imaging emission nebulae, invest in a good quality hydrogen-alpha filter for your camera. Since all emission nebulae are naturally red in visible light they really pop out through this narrowband filter. Stars will be much smaller and the 'empty' space will be much darker, emphasising the nebula. Using the data through an Ha filter as luminance (as is the case in this image) will show the inner structures much better than an ordinary L-RGB image, and will also help you image through light-polluted skies. As a bonus, you can mount the Ha image as a black and white retro photo on your living room wall."

◁ Lunar X and V

Vicki Pink, Southampton, 9 July 2019

Vicki says: "This was a challenge as the sky was still very bright so getting focus was tricky. The X and V were visible and the seeing seemed fairly steady. This is a five-panel mosaic, comprising of 100 frames each from a SER file."

Equipment: Altair GPCAM2 290C camera, Sky-Watcher Explorer 130P Newtonian, Sky-Watcher SynScan AZ Go-To mount
Exposure: 100 frames
Software: Microsoft ICE, RegiStax, Photoshop

▽ Mullinger Milky Way

John Carter, South Australia, 30 June 2019

John says: "Mullinger Swamp is a wonderful spot for capturing reflections on water. I went out early in an attempt to capture the Milky Way as it set from the other side of the swamp. My only regret was not wearing gumboots so I could get farther into the water and reduce some of the clutter on the right-hand side of the image!"

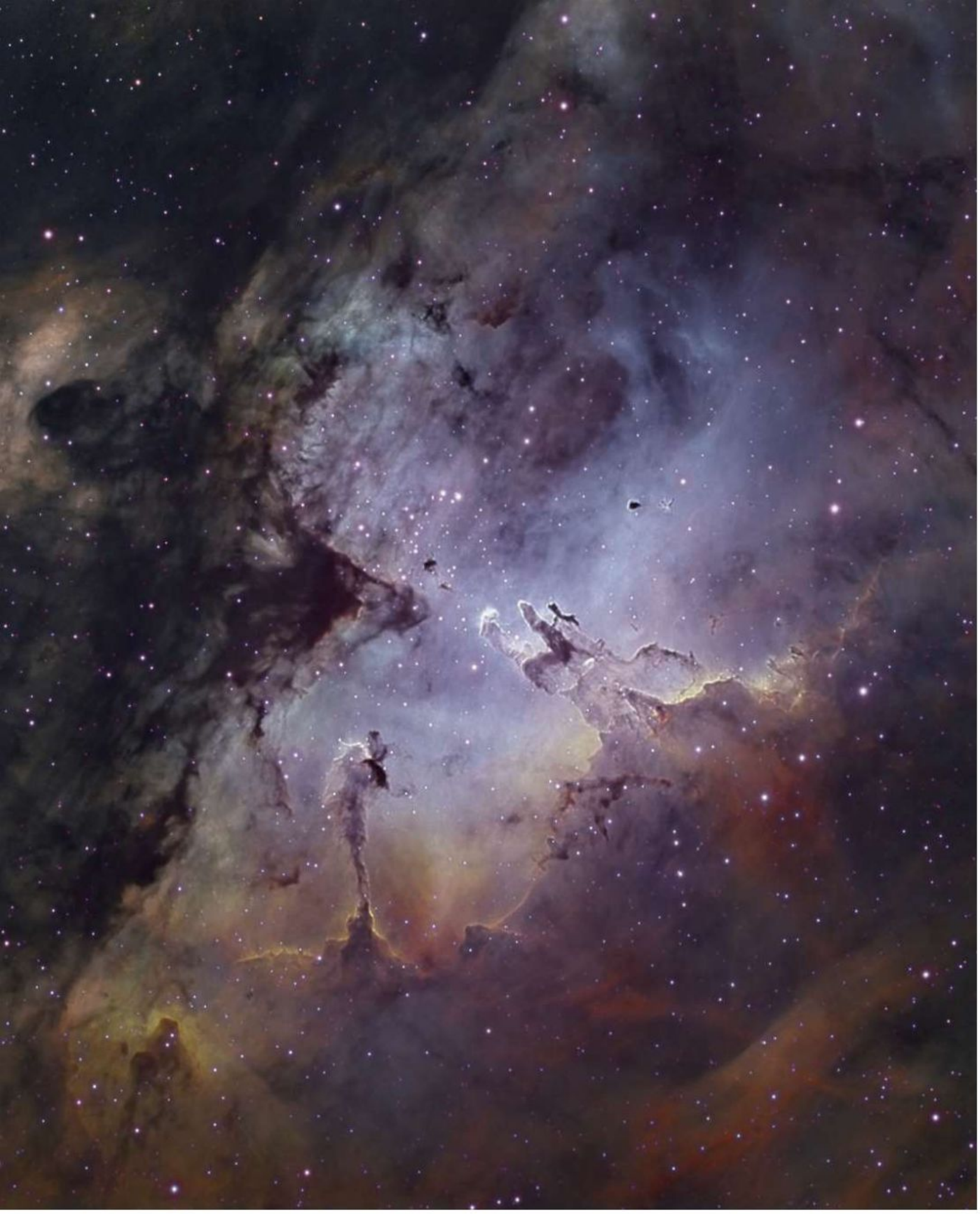
Equipment: Canon EOS 6D DSLR camera, Samyang 12mm lens
Exposure: ISO 10,000, 6x20" sky, 6x40" water, ISO 1600, 16' foreground
Software: Lightroom, Sequator, Photoshop

△ Sh2-174

Douglas Struble, Michigan, US , 22 June–19 July 2019

Douglas says: "Sh2-174 is an ancient planetary nebula that is dispersed and faint. I spent just under 58 hours between Ha and OIII. Even then, I had to remove stars to bring out more detail and layer them back in."

Equipment: ZWO ASI 1600MM camera, Stellarvue SVX102T-R apo triplet refractor, Astro-Physics Mach1 mount **Exposure:** 896x120" Ha, 840x120" OIII **Software:** SGPro, PHD2, PixInsight, Photoshop



◁ The Eagle Nebula

David Wills, Oria, Spain, 23–30 June 2019

David says: "I had wanted to capture this image for ages, but due to UK weather and work I never had the time. Having recently moved to Spain to start a remote telescope hosting site, I finally got the opportunity. I really enjoyed the processing as the quality of the data was great."

Equipment: Xpress Trius SX-694 mono CCD camera, TEC 140 f/7 apo refractor, iOptron CEM60 mount
Exposure: 10x1,800" Ha, 7x1,800" OIII, 9x1,800" SII **Software:** PixInsight, Photoshop

▽ Noctilucent clouds

Peter Lee, Wiltshire, 21 June 2019

Peter says: "I stepped out into my north-facing garden and saw a glowing sky with what looked at first to be some odd-shaped clouds. I grabbed my binoculars and could see these amazing patterns in the night sky. I got my camera and took some photos. I had never seen anything like this before."

Equipment: Canon EOS 700D DSLR camera, Tamron 70-300mm lens
Exposure: ISO 3200, 1/3"

The North America Nebula ▷

Paul Gordon, Rochford, 22 July 2019

Paul says: "There was haze and light pollution to the south of my garden so I chose a target towards the zenith. After stacking – with dark, bias and flat frames – I believe this is my best image of this nebula."

Equipment: Canon EOS 60Da DSLR camera, Borg 77EDII refractor, Sky-Watcher HEQ5 Pro SynScan mount **Exposure:** ISO 800, 34x3' **Software:** DeepSkyStacker, Photoshop, IrfanView

△ Lunar eclipse

Darshna Ladva, London, 16 July 2019

Darshna says: "This single image is from a time lapse. As the Moon cleared the haze and the rooftops of the London skyline, it was a beautiful sight. I started imaging the rise with the longer focal length of the scope and moved to a wide-angle lens."

Equipment: Nikon D5500 DSLR camera, Altair 60EDF refractor, Sky-Watcher Star Adventurer mount **Exposure:** ISO 400, 1/8" **Software:** Lightroom

◁ Saturn

Sue Silver, Sheffield, 22 July 2019

Sue says: "Saturn is quite a challenge this year as it's low in the sky, but I managed to get this on the second attempt as it appeared between the rooftops. The seeing was much steadier and I'm pleased with the results despite the short time available."

Equipment: ZWO ASI 120 MC-S camera, NexStar 6SE Schmidt-Cassegrain, Celestron CG-5 mount **Exposure:** 6x45" **Software:** AutoStakkert!, RegiStax, PaintShop Pro

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86

Pin-sharp views right to the edges? We find out if Meade's LX65 package delivers on its coma-free promises

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HOW WE RATE

Each product we review is rated for performance in five categories. Here's what the ratings mean:

★★★★★ Outstanding ★★★★½ Very good
★★★½★ Good ★★½★★ Average ★½★★★ Poor/avoid

Meade LX65 Series 8-inch ACF telescope

A capable, compact and colourful telescope with a wide selection of extras

WORDS: PAUL MONEY

VITAL STATS

- **Price** £1,315
- **Optics** 203mm (8-inch) SCT with Advanced Coma-Free (ACF) optics
- **Focal length** 2,032mm, f/10
- **Mount** Single arm alt-azimuth
- **Hand controller** AudioStar
- **Database** Over 30,000 objects, including IC, Messier, NGC and more
- **Weight** 18kg
- **Supplier** OpticStar
- **Tel** 0161 969 9008
- **www.** opticstar.com

ALL PICTURES: WWW.THESECRETSTUDIO.NET

Meade is a long-established manufacturer and brand with a huge range of telescopes, mounts and accessories, so we were pleased for the chance to review its latest LX65 mount and ACF (Advanced Coma-Free) 8-inch telescope. The system comes with a stainless steel tripod, 26mm eyepiece, Red Dot Finder, star diagonal, bubble level with compass, and a DVD with planetarium software.

The LX65 mount is a single straight arm alt-azimuth Go-To mount, powered either by eight C-type batteries or an external 12V power source. An interesting addition is that there are two Vixen-style saddles, the main one for holding the supplied telescope and an additional one on the outer side for a second telescope that weighs up to 3.2kg. This second saddle can be adjusted to line up the view exactly with the primary instrument. It's ideal for adding a rich field refractor to give wide views of the same target. The mount is sturdy despite its outer plastic casing, which looks good in the blue livery complementing the optical system.

All in hand

Controlling the mount and providing functionality is the AudioStar hand controller. This plugs into the topmost of the ports on the back of the mount arm, clearly labelled HBX. A removable bracket allows the hand box to be attached to the mount for convenience. The AudioStar features 30,000 objects covering all the main catalogues of deep-sky targets, such as Messier, Caldwell, NGC and IC, along with Solar System targets of the planets, asteroids and comets. Other options include named stars, variables and doubles along with the choice to take a tour of 'Tonight's Best' – which automatically selects the best night-sky objects for that time and location – so there is plenty to explore. The AudioStar also features audio voiceovers for 500 objects in the database.

The optical tube is a Meade ACF catadioptric telescope with a diameter of 203mm (8 inches) and a ▸

Optimal optics

The 8-inch ACF is a catadioptric telescope with Meade's own specification Advanced Coma-Free (ACF) optics. This gives a flatter, coma-free surface right to the field edges and uses a slightly larger Borosilicate glass primary mirror with Ultra-High Transmission Coatings for brighter views of your targets. It has an 8-inch (203mm) primary mirror with a focal length of 2,032mm giving f/10, technically making this a 'slow' system. This means that, for any given eyepiece, the magnification provided is higher than with a shorter focal length system such as f/5 or f/6. However, this makes it ideal for high-resolution planetary and lunar viewing or imaging yet still gives good views of a wide range of deep-sky targets, especially double stars. The catadioptric design makes such a long focal length quite compact, meaning that transportation and use are easier, with the optical tube assembly only weighing 5.5kg. It performs well, but a dewshield should be added as the front corrector plate can dew up if you don't have access to a dew heater.

SCALE

Finder, eyepiece and diagonal

The finder is a zero-magnification Red Dot Finder with variable brightness. It worked well, but could dew up over prolonged periods. A star diagonal and a Series 4000 26mm/1.25 inch eyepiece, giving a useful magnification of 78x, are included. The focuser is at the back of the tube and was smooth in use.

Ports

On the rear of the L-shaped mount are various ports: HBX for the AudioStar hand controller (Meade call it the Handbox), with the on/off switch and red LED indicator light coming next. Either side of the 12V power connection port are two aux inputs for Meade accessories and future enhancements.

Tripod and holders

The steel tubular-legged tripod provides good support for the LX65 and has adjustable legs, allowing for a range of heights for a more comfortable viewing position. The eyepiece spreader tray gives the tripod rigidity and can hold three 1.25 inch eyepieces for easy swapping in use.

FIRST LIGHT

KIT TO ADD

1. Meade Series 6000 80ED apo triplet refractor

2. Meade LPI-G monochrome or colour camera

3. Meade Series 5000 HD-60 eyepiece set

▸ focal length of 2,032mm giving a focal ratio of f/10. Combined with the supplied 26mm Series 4000 Super Plössl eyepiece, it gives a magnification of 78x. In our visual test of the field of view it was pin sharp across the whole view – indeed, we also used our 32mm eyepiece, giving 63.5x, and it was still sharp to the edge.

We set up and followed the instructions for levelling the system and chose the two star Easy Align option. Once alignment was complete, we found all our chosen targets reasonably close to the centre of the view of the 26mm eyepiece. We took a tour of the double stars on offer and were impressed with the vivid colours the optics gave of Albireo, which at 78x was lovely and wide.

Jupiter suffered from some low haze, but clearly showed belts, a hint of the Great Red Spot and plumes in the North Equatorial Belt, along with its four Galilean moons. Saturn was slightly better. Using our own higher power eyepieces, we could see the Cassini Division, north polar haze and northern belt, as well as carefully spotting four of its moons. A week later the Moon was viewable and there were plenty of stunning craters to wow us.

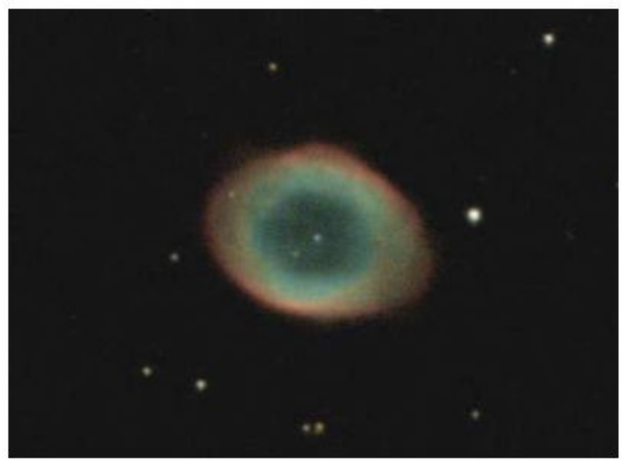
The light summer nights made hard work of deep-sky objects, but we enjoyed a tour of M27, M57, M11, M13 and M3, along with just about getting the Double Cluster with the 26mm eyepiece and spotting the galaxy pair of M81/82, each in a separate view.

Although you can easily image the Moon and brighter planets with this system, it is not primarily marketed for astrophotography. Yet, with the advancement of cameras – DSLR and CMOS or CCD – it is now possible to capture deep-sky images of brighter targets, using short exposures, high ISO values and stacking techniques. We took images of the Moon using a webcam and smartphone, and used our GPCAM 290C CMOS camera and Canon 50D DSLR to image a few deep-sky targets with interesting results (see images, right). Indeed, the LX65 Series 8-inch ACF is a capable system and we enjoyed using it.

VERDICT

Assembly	★★★★★
Build & Design	★★★★½
Ease of use	★★★★½
Features	★★★★☆
Optics	★★★★½
OVERALL	★★★★½

The Moon's Mare Crisium, captured with a GPCAM 290C, using a stack of 587 frames



▲ M57, again with a GPCAM 290C, stacking 42 x 5-second exposures

▲ Pairing with a Canon 50D captured this image of M11, stacking 4 frames of 5-second exposures, ISO 3200

AudioStar hand controller

The AudioStar hand controller is easy to use and has a database of 30,000 objects. It features an in-built speaker and audio descriptions for many of the brighter objects, adding an extra dimension to your viewing pleasure.

LX65 alt-az Go-To mount

The base contains the electronics and gears for alt-az operation and a battery compartment. Although it's a single arm design, it can carry two telescopes via the Vixen-style saddles. It has an integrated carry handle and the hand controller can be attached for ease of use.

WWW.THESECRETSTUDIO.NET, PAUL MONEY X 3

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Altair Astro Hypercam 183M Pro Tec 4GB mono CMOS camera

An electronically cooled camera that will meet your deep-sky imaging needs

WORDS: TIM JARDINE

VITAL STATS

- **Price** £975
- **Sensor** Sony Exmor R BSI IMX183
- **Sensor size** 5440x3648 pixels
- **Built-in memory** 4GB
- **Bit depth** 8-bit, 12-bit or 16-bit stretched
- **Size** 104mmx85mm diameter
- **Weight** 0.58kg
- **Supplier** Altair Astro
- **Tel** 01263 731505
- **www.** altairastro.com

WWW.THESECRETSTUDIO.NET, TIM JARDINE

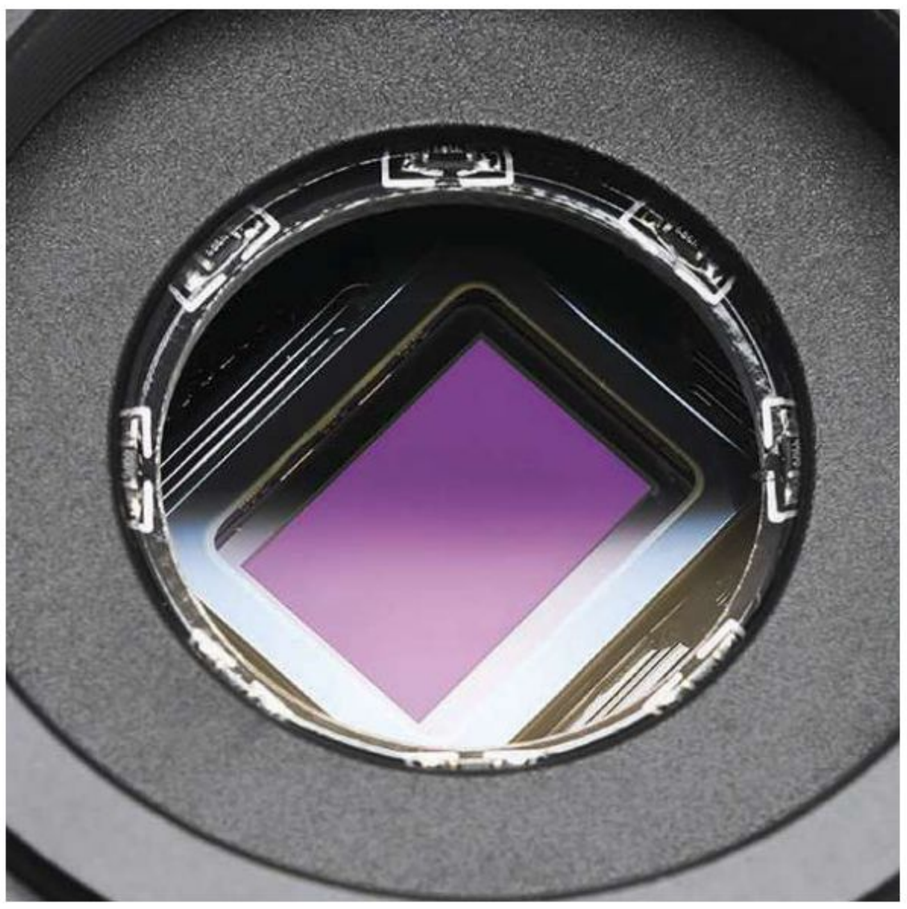
Having previously reviewed Altair's capable 183 Hypercam family, we couldn't help but wonder about the potential of these cameras with the addition of electronic cooling. With the Hypercam 183M Pro Tec 4GB we get a beefy upgrade to the standard models that, with its precise temperature control, helps to realise its full potential as a deep-sky astrophotography camera.

Software for the camera is free, but not included in the package, so we followed the link provided and installed the latest version of Altair Capture. We used our existing USB 2.0 arrangement (forgoing the USB 3.0 port and cable provided), but the software immediately recognised this and in just a short time the camera was ready to use – ideal for amateurs (the Pro in the name relates to the performance of the Hypercam rather than the intended expertise of the user).

Powerful sensor temperature reductions, in this case down to –45°C below ambient temperature, require a dedicated power supply, and a 12V power supply unit suitable for interior use is included. The fan and thermoelectric cooling (TEC) system only operate when the camera is connected to a computer, and the required temperature is easily set within Altair Capture. The manufacturer website states that no practical benefit is achieved by cooling the IMX183 sensor below –15°C. In our tests we found that going lower than –20°C pushed the limits of the inbuilt anti-dewing features, leading to an undesirable dew spot forming in the middle of the optical window.

Testing conditions

Midsummer skies offer precious little opportunity for deep-sky imaging and although the Hypercam offers various settings for planetary or lunar images, we thought it prudent to concentrate on acquiring typical summertime deep-sky images, relying on narrowband filters to make up for the lack of astronomical darkness. Short focal length refractors would make an ideal ▸

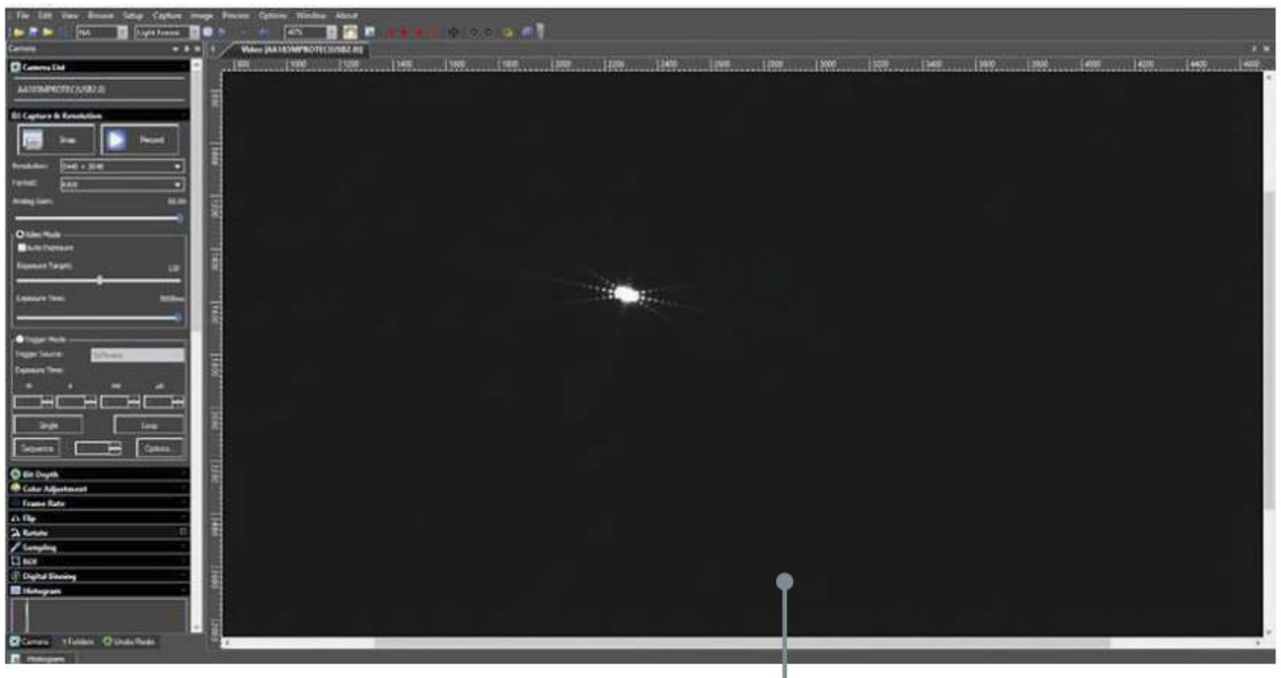


Superior sensor

The camera's Sony IMX183 CMOS sensor offers 20MP images, with a 5440x3648 array of 2.4x2.4 micron pixels. Although seemingly impossibly tiny, these pixels benefit from technology known as Back Side Illumination (BSI), increasing their sensitivity and effectiveness.

The sensor QE, or quantum efficiency, is given as a healthy 84 per cent, which essentially means that 84 per cent of the light photons that hit the sensor are converted into the electronic signal that becomes our image. In actual use, we were impressed with the camera capturing very faint narrowband light in both hydrogen alpha and oxygen (OIII) wavelengths, in exposures that are relatively short compared to CCD-based cameras.

As the IMX183 sensor is just 16mm across the diagonal, smaller, less expensive 1.25-inch filters can be used – and indeed to take colour pictures with this mono version of the Hypercam, a LRGB filter set is required, while the addition of narrowband filters will maximise the amount of nights that are useable for astro imaging.



Capture software

Altair Capture is included via download, offering full control of all the camera's functions and providing simple image- or video-capturing ability. Lucky imaging or Electronically Assisted Astronomy options are available, working well with sensitive cameras like the Hypercam 183M.

Build and design

It's a chunky 580g, but the Hypercam 183M is well-balanced and nicely finished, offering solid cable connections and smooth surfaces. The internal fan is quiet and a bank of LEDs highlight the camera's working functions.

Heated optical window

Sudden drops in temperature can lead to dew spots or even ice forming on surfaces within electronically-cooled cameras. The optical window in the Hypercam 183M is heated to avoid this. Replaceable desiccant (drying agent) in a separate chamber offers further protection.

USB connectivity

The Hypercam 183M is operated through a 1.5m USB 3.0 cable, but it's fully compatible with USB 2.0 too. On the camera's rear, a powered USB 2.0 hub with two slots allows for a guide camera or filter wheel to be connected.

FIRST LIGHT

Armoured plastic case

The camera comes with a lockable and waterproof plastic case. Sturdy and foam-lined, it has cut-outs to locate the camera, cables, 12V power supply unit and accompanying accessories.

KIT TO ADD

1. Altair Quad 70mm ED APO astrograph

2. Altair 2-inch narrowband SHO filter set

3. Altair 2-inch triband filter for luminance

► match for this camera, but to increase contrast in poor skies we opted for a 6-inch, 1,050mm telescope as a companion. Turning first to the Dumbbell Nebula, M27, we ran a series of 10-minute exposures, with a gain setting of 1.

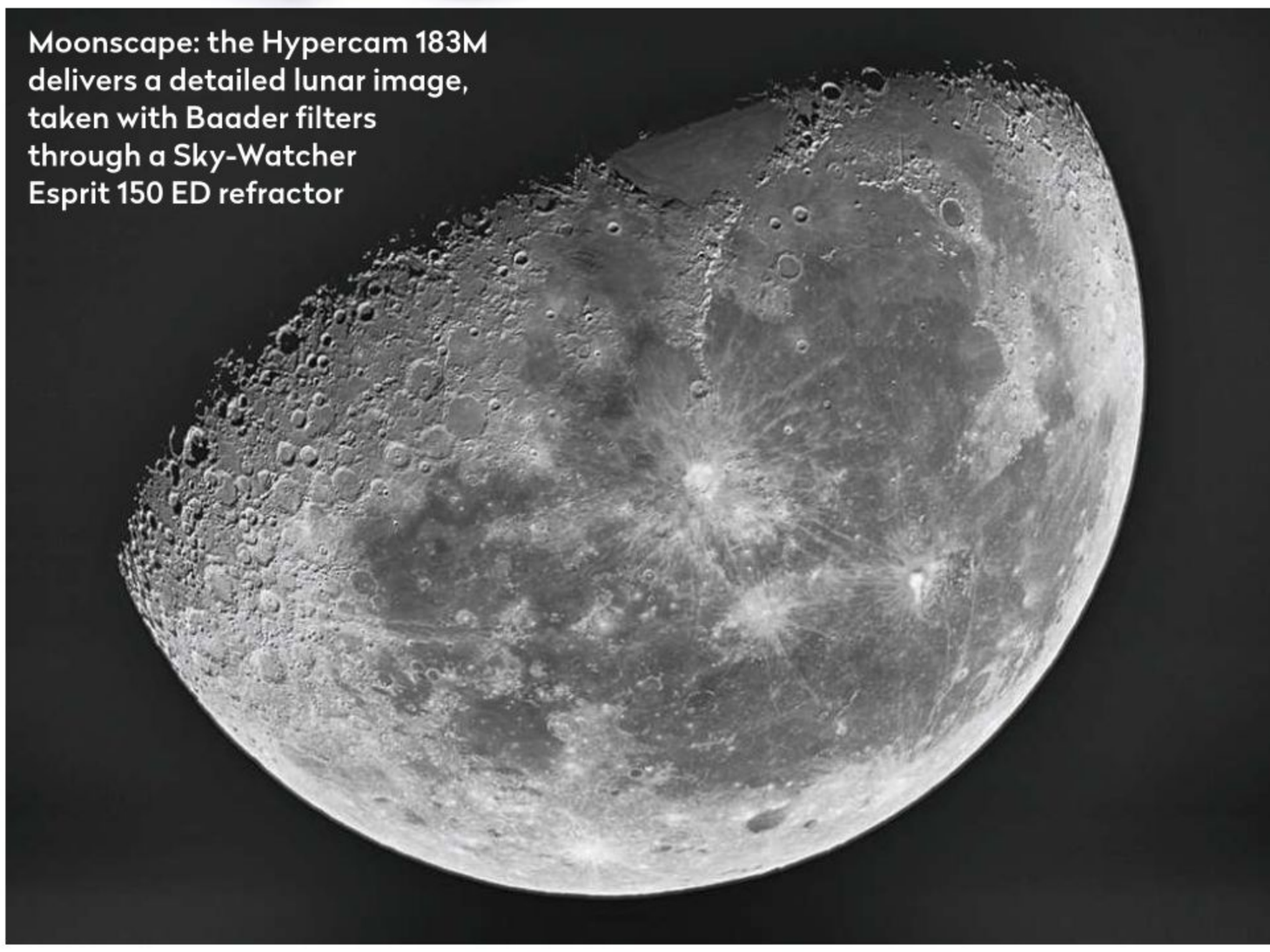
The results were very impressive, even from a single exposure. Unwanted image artefacts that were quite evident in the standard Hypercam variants were pretty much eradicated. As anticipated, a bright, 'star burst' artefact is produced on the right-hand side of the image as a result of the CMOS chip hardware, but this is effectively nullified by taking matching dark frames at the same temperature and same duration as the light frames.

We were really impressed with the camera's ability to pick up even the faintest outer reaches of the Dumbbell Nebula in just 10-minute exposures. However, this limited us to just a handful of useful exposures per session, so we cut the exposure time to five minutes and increased the gain setting to compensate, meaning we could double the amount of pictures acquired. Being able to easily manipulate the camera settings to suit the available conditions in this way enabled us to make the most of the limited sessions we had. We could easily take matching dark images, even during daytime, and felt that the Hypercam 183M Pro Tec is an ideal camera for getting the best out of variable sky conditions.

We couldn't resist some pictures of a frame-filling Moon, and even pointed the camera towards low-lying Jupiter. To get the best results from these targets, a fast frame rate is preferred. On our i7 8GB laptop, the highest frame rate we could achieve in USB 3.0 mode was 35.5fps, using a region of interest (or ROI) of 1280x720 in 8-bit mode. The USB 2.0 connection was considerably slower, but frame rates vary widely depending on individual computers.

With temperature-controlled imaging, the Hypercam 183M Pro Tec is a reasonably priced and highly capable astronomy camera, with excellent deep-sky astrophotography results.

Moonscape: the Hypercam 183M delivers a detailed lunar image, taken with Baader filters through a Sky-Watcher Esprit 150 ED refractor



◄ Dumbbell Nebula, M27, produced by stacking, stretching, combining and tweaking two sets of exposures (14x10 minutes with a 7nm Ha filter and 5x10 minutes using a 8.5nm OIII filter)

VERDICT

Build and design	★★★★½
Connectivity	★★★★★
Ease of use	★★★★½
Features	★★★★☆
Imaging quality	★★★★½
OVERALL	★★★★½

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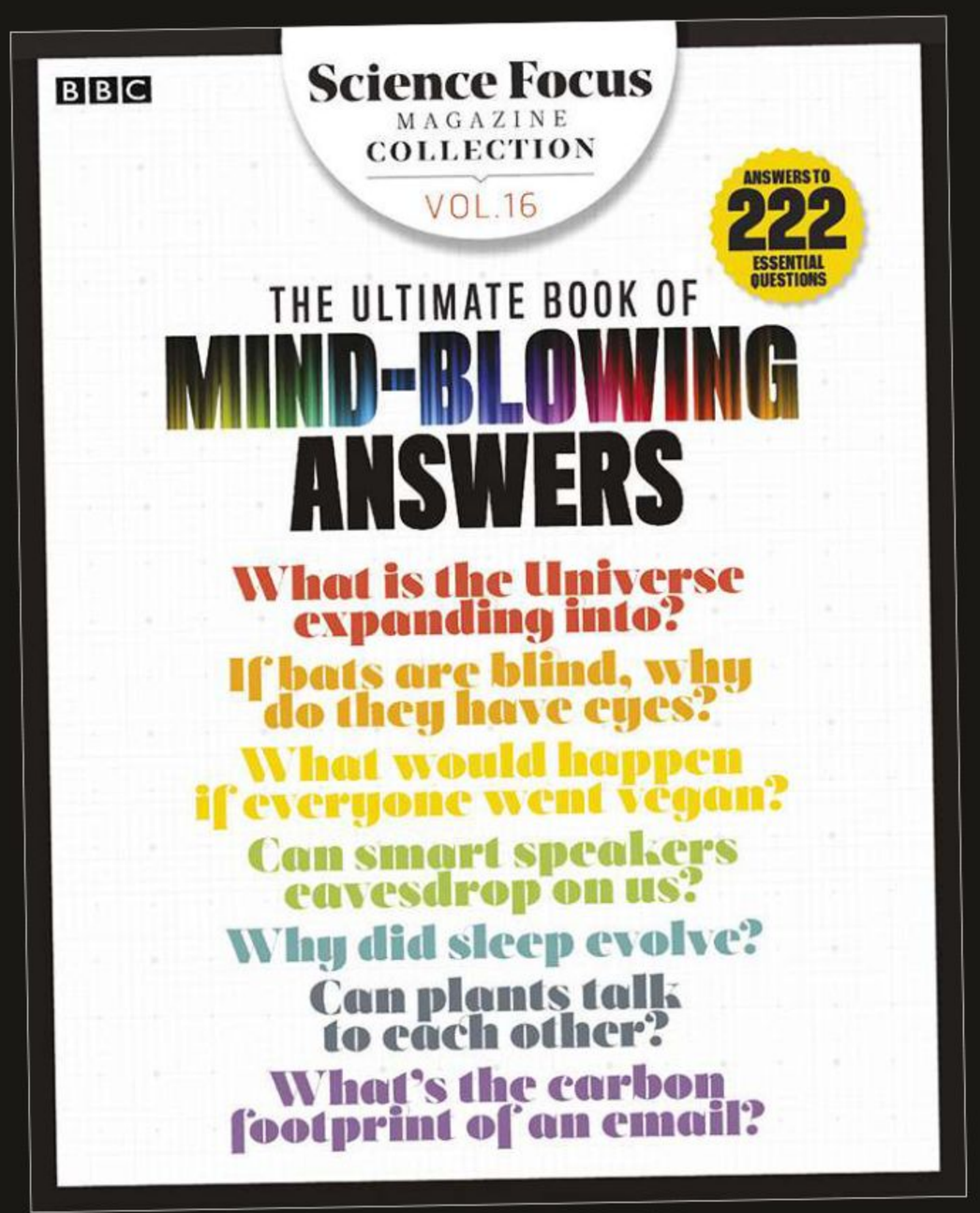

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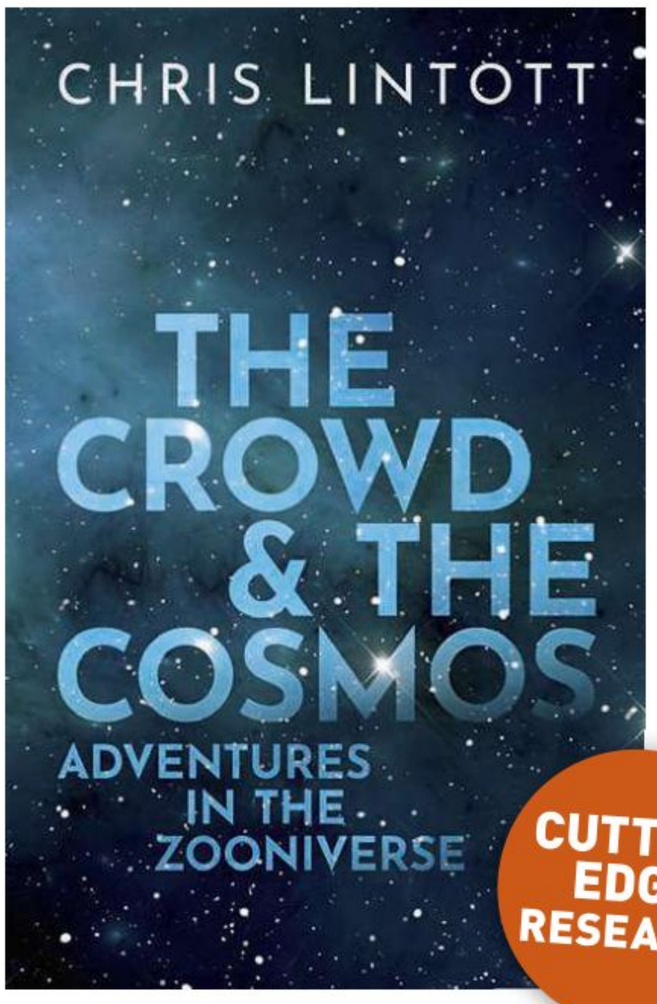


CUTTING EDGE RESEARCH

The Crowd & The Cosmos: Adventures in the Zooniverse

Chris Lintott
Oxford University Press
£20 ● HB

When was the last time you discovered a planet? For Australian car mechanic Andrew Grey it was in April 2016. Grey was one of the volunteers of Planet Hunters, a citizen science project to search data from NASA's Kepler Space Telescope for transiting exoplanets. In 2018, he was listed as co-author on the discovery paper in *The Astronomical Journal* of no less than five planets orbiting the star K2-138.

Andrew's story, briefly retold in the preface of *The Crowd & The Cosmos* by Professor Chris Lintott is a great example of the power of the crowd. So much data, so few professional astronomers, so little time: that's where citizen science comes in. Over ten years ago, Lintott started Galaxy Zoo, a citizen science project to classify galaxies. It was an instant success. Before long, with the help of others, he initiated similar 'distributed science' projects like Solar Stormwatch (on solar flares) and Moon Zoo (on lunar crater counts). At present, the Zooniverse encompasses over 70 projects in various areas of science, including Penguin Watch. In his entertaining book, Lintott describes the origin and evolution of the Zooniverse, with a strong focus on the astronomy projects.

You will read all about famous discoveries like Hanny's Voorwerp and Tabby's Star, undoubtedly well-known to most readers of *BBC Sky at Night Magazine*. But the real strength of the book is in the accessible description of current astronomical research topics and future big-data facilities like the Large Synoptic Survey Telescope. As viewers of *The Sky at Night* will agree, Lintott is a great storyteller with a knack for witty anecdotes. Once you start reading, his book is hard to put away. It's as if he's spending an evening in the pub with you across the table over a beer. Unfortunately, *The Crowd & The Cosmos* does not contain the personal stories from the participants of projects like Galaxy Zoo, Planet Hunters or Space Warps; stories that would have further inspired readers of the book to take part themselves. After all, as the author writes on the last page, the Zooniverse needs you. ★★★★★

▲ **Back garden astronomers are now at the forefront of discovery thanks to the Galaxy Zoo project**

PATRICK EDEN/ALAMY STOCK PHOTO

***Govert Schilling** is an astronomy writer and author*

Interview with the author Chris Lintott

How have advances in technology influenced citizen science?

Citizen science is an old idea for astronomers. Observers with back garden equipment have been monitoring the planets, finding supernovae and counting meteors for centuries! The advance in technology has created new opportunities – professional surveys of the sky produce a wealth of data, and the advent of the web means we can all get our hands on it.

What have been Galaxy Zoo's biggest discoveries?

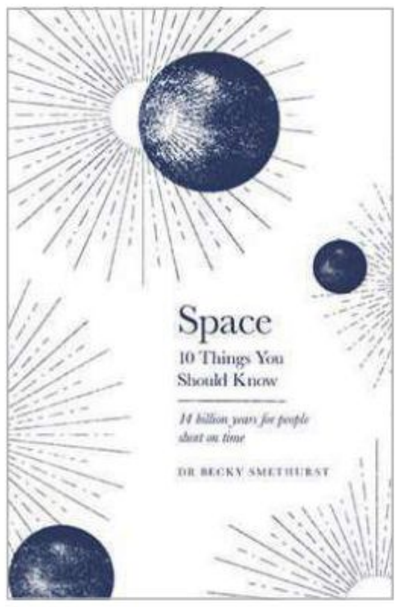
Probably my favourite is Hanny's Voorwerp, a galaxy-sized glowing gas cloud discovered by Dutch schoolteacher Hanny van Arkel. The gas in the Voorwerp is excited by the neighbouring galaxy, which would once have been our nearest quasar. A discovery that started with Hanny asking a simple question "What is this thing?" ended up involving observatories around the world and in space to find an answer.

Are humans more useful than smart computers?

Since we started Galaxy Zoo people have been assuming computers would take over, and it's true that automated pattern recognition has come a long way in the last decade. Combining human and machine classification gives better results than either on their own. The machines do the bulk of the work, but you still get that human ability to be surprised and to deal with the unexpected. We need to work with our robot colleagues, not see them as competition!

***Professor Chris Lintott** is a co-presenter on* The Sky at Night *and lead of numerous citizen science projects.*

Space: 10 Things You Should Know



Dr Becky Smethurst
Orion Publishing Co
£9.99 ● HB

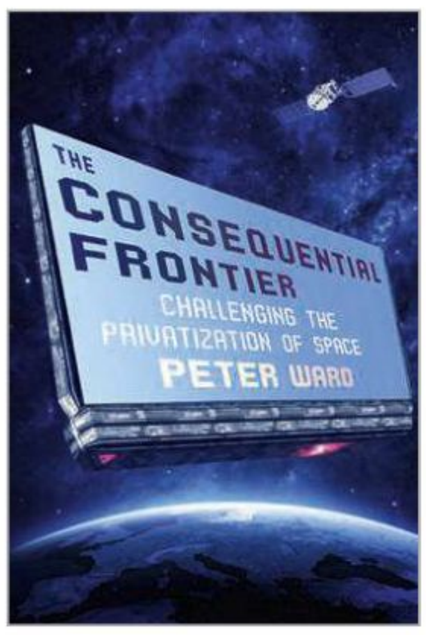
Dr Becky Smethurst has a wonderful gift for communicating some extremely exciting but also tough astrophysics in 10 bite-sized essays. If you would like to know about supermassive black holes, the hunt for exoplanets and the expanding Universe (plus a lot more), then this book is a nice starting point.

I enjoyed the conversational writing style and the divergences which come with this. It did make me feel as though Dr Becky was sitting next to me. My favourite chapter is actually the last, which touches on the nature and importance of searching for the unknown knowns. There are some fantastic stories of citizen scientists who have made some amazing discoveries and contributions to research. Even though I really like this book, there are some niggles. Although each essay can be read separately, I felt their ordering could have been better in the book as a whole. Some concepts were better explained in a chapter after they were initially introduced in a previous one. I did also notice some slight inaccuracies, for example the gravitational-wave detectors LIGO and Virgo are actually three detectors (not two) and are not located underground. As far as I know, we've also never detected gravitational waves from merging black holes in the Milky Way. Despite this though, I would recommend *Space: 10 Things You Should Know*. There's something wonderfully inspiring that the writer manages to communicate through the pages, and I closed the book feeling a bit more excited about my own research. Thanks for reminding me Dr Becky!

★★★★☆

***Laura Nuttall** is a senior lecturer in gravitational waves in the Institute of Cosmology and Gravitation at the University of Portsmouth*

The Consequential Frontier



Peter Ward
Melville House
£25 ● HB

From Moon bases to asteroid mining, it's no longer a question of whether we can achieve such ambitious space goals, but rather whether we should colonise space in the first place. In *The Consequential Frontier* we encounter the past, the present and the future of space travel and how our motivation has changed with time.

In the past, although fuelled partially by competition, the pursuit of knowledge and the race to the Moon were intertwined. But as space becomes more affordable thanks to companies like Space X and its visionary CEO Elon Musk, science takes a back seat and money is now the driver.

Looking to the future, this book highlights exciting possibilities for humankind while also serving as a warning. Back in 2007 the $20 million Google Lunar X Prize was promised to the first private company to land a robotic spacecraft on the Moon. Although unclaimed, this challenge enabled companies like iSpace to secure investments for its Moon Valley – a system supported by space economy.

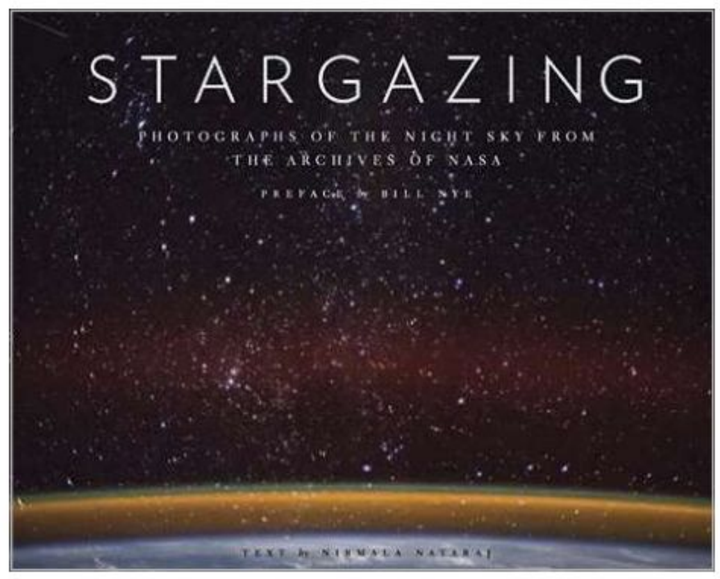
The problem is, and this is one of the key messages of the book, there is only one measure in place to prevent extra-terrestrial resources being exploited – the Outer Space Treaty – and many are already looking for ways to bypass it for profit. Exploring space is incredible, but we need to remember to look after it too.

Although this book is slow in the beginning, it soon picks up. So dust off your space boots, possibly a law book too, and get ready to learn all about the next era of space travel.

★★★★☆

***Amber Hornsby** is a postgraduate researcher at Cardiff University*

Stargazing



Nirmala Nataraj
Chronicle Books
£25 ● HB

Stargazing begins with an engaging introduction to the wonders of the cosmos contributed by Bill Nye, the well-known American science populariser. Approximately 100 images follow, ranging from rocket exhaust plumes arcing across the sky to views of galaxies far beyond our own Milky Way. At first glance the editorial policy adopted in *Stargazing* seems to be targeted towards a particular aspect of NASA's vast image archive. Many of the illustrations throughout the book show how Earth's atmosphere affects what telescopes and cameras can actually record; often with beautiful if somewhat hazy results. This theme on its own could have worked rather nicely. After all, the thin layer of oxygen and nitrogen that separates our planet from the unforgiving vacuum of space has interfered with our understanding of the cosmos throughout most of human history, so it would be an interesting subject to explore in its own right.

However, a selection of images from space telescopes operating far beyond any possibility of atmospheric disturbance is thrown somewhat randomly into the mix, and the final result is a lack of focus, which is not such a good thing for a book on astronomy.

This modest selection of images is ultimately slightly underwhelming. Stargazing is a decorative but slightly overpriced volume, and it would make a pleasant gift for friends or relatives with a casual interest in space, but serious enthusiasts will find that it falls well short of 'must-have' status.

★★★☆☆

***Piers Bizony** is the author of The Space Shuttle and other books on spaceflight*

Elizabeth Pearson rounds up the latest astronomical accessories

GEAR

1 Star Rover app

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www.eefan.net

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2 Personalised constellation ring

Price £70 · **Supplier** Not on the High Street
www.notonthehighstreet.com/jessicagreenaway

Wear your favourite constellation wherever you go with these handmade rings. Twelve constellations are available, including Andromeda, Orion and Cygnus. The chunky design would suit both men and women.

3 Space Shuttle stationery set

Price £7.99 · **Supplier** The Present Finder
Tel 0333 240 6092 · **www.thepresentfinder.co.uk**

Prepare for take-off and the school year with this set. It includes a ruler, multi-colour pen, two pencils and a Space Shuttle-shaped rubber. The pen and pencil fit into the eraser to resemble the Shuttle's fuel tanks.

4 Extremities thermal arid beanie waterproof hat

Price £19.99 · **Supplier** Sub Zero Store
Tel 0116 240 2634 · **www.subzerostore.co.uk**

Waterproof yet breathable, this stretchable beanie will keep your head warm and dry for observing sessions, while the insulating polyester inner ensures you'll stay comfortable.

5 Mini autoguiding setup

Price £250 · **Supplier** Altair Astro
Tel 01263 731505 · **www.altairastro.com**

This kit has everything you need to start auto-guiding your scope within minutes of taking it out of the box. It comes with an Altair Mini Guide Scope and Mono Guide Camera, along with the cables and rings you'll need. Free controlling software can be downloaded.

6 Baader Steeldrive II motor with focus controller

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Shaoni Bhattacharya interviews Professor Karen Masters

Q&A WITH AN EXTRAGALACTIC ASTRONOMER

By taking part in the Galaxy Zoo project, citizen scientists may have overturned a century-old galaxy classification system

What is the Galaxy Zoo project?
It's a website project that has been running for 12 years, where we invite anyone to look at galaxies and answer questions describing the different structures they see. For example, they may see spiral arms, bars (straight formations across galaxies with a concentration of stars) or sometimes no structure at all. We collect information from about 30-40 people per galaxy so we're able to get a consensus crowd-sourced answer for what is visible in that image of that galaxy. We use this to investigate a galaxy's evolution.

▲ A spiral galaxy with a bar. Recent findings question the correlation between the size of the central bulge and how tightly the arms are wound

NASA, ESA, AND THE HUBBLE HERITAGE TEAM (STSCI/AURA); ACKNOWLEDGMENT: P. KNEZEK (WIYN)

What can you tell about a galaxy's evolution from its shape?
The shape tells you quite a lot about how the galaxy is assembled over time and also about the motions of stars in the galaxy now. We see spirals and discs where the stars are all moving in the same plane. Smoother galaxies, known as ellipticals, are less likely to have so much of that coherent motion, but have stars in a more random motion. That is most likely a characteristic of having been assembled from lots of galaxies that merged together and came in at different angles.

What did citizen scientists do in your new spiral galaxy study?
The first thing they had to do was find all the spiral galaxies in the original list of 250,000 galaxies from the Sloan Digital Sky Survey (SDSS). In the end, they had about 6,000 galaxies. Most people probably look at between 20 to 50 galaxies, and they compared their answers to classifications from other catalogues.

What is Hubble's tuning fork?
It is a galaxy classification scheme invented by Edwin Hubble in the 1920s. The diagram used to represent it resembles a tuning fork because the spiral galaxies are split into two tines – one showing the spiral galaxy sequence with a bar and the other showing those without a bar. Then the elliptical galaxy sequence is a single line that meets them, forming the handle of the tuning fork.

Hubble talked about the size of the bulge – the central concentration of light you find in some spiral galaxies – and its correlation to how the arms are wound. He claimed that most spiral galaxies had a big bulge and tightly wound arms, or a small bulge and loosely wound arms.

What did your study show?
The surprising find was that the bulge size did not correlate with the arm winding. The expectation from the Hubble tuning fork is that spiral galaxies with small central light concentrations would have loose arms and those with large central light concentrations would have tight arms, making almost a full circle. When we plotted the observations for these two things in our study, we didn't see that correlation.

How do your findings help us understand galaxies better?
I think we are dealing with the questions of what spiral arms are, and what forms them. We have known about spiral arms for about 150 years and theories attempting to explain what they are have been well established since the 1960s. So it was a surprise to me here, in 2019, to be thinking that maybe we don't really have a good agreement over what is the dominant mechanism by which spiral arms form.

There are theories that predict Hubble's correlation. People often talk of spiral arms as being density waves, much like with a traffic jam – where you get a build up of cars and then you suddenly pass through it. The stars are doing that in the density wave model: they pile up and then pass through it. A static density wave is the model everyone said explained the spiral arm because it fitted the tuning fork, but we are saying it doesn't have to be that. We don't see Hubble's correlation.

Prof Karen Masters is an associate professor of physics and astronomy at Haverford College in Philadelphia, USA, and the Galaxy Zoo project scientist

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THE SOUTHERN HEMISPHERE

With Glenn Dawes

With six on offer, see how many you can spot during this super month for planet hunting

When to use this chart

1 Oct at 24:00 AEDT (13.00 UT)
15 Oct at 23:00 AEDT (12.00 UT)
31 Oct at 22:00 AEDT (11.00 UT)

The chart accurately matches the sky on the dates and times shown for Sydney, Australia. The sky is different at other times as the stars crossing it set four minutes earlier each night.

OCTOBER HIGHLIGHTS

Mercury has its best evening return for 2019 this month. This evasive planet will set just after the end of twilight. As it heads towards inferior conjunction, it grows from 5.3 arcseconds on the 1st to 8.5 arcseconds on the 31st. In the same period the visible phase shrinks from a gibbous, near-full Moon to a crescent (5-day-old) shape. On 29 October, Mercury, Venus and a thin crescent Moon are within 10°, forming a near straight line. On 30 October, Mercury and Venus are closest, only 3° apart.

STARS AND CONSTELLATIONS

Low in the northern evening sky, in the lower right of the Square of Pegasus, lies the Andromeda Galaxy (M31). This hazy area visible to the unaided eye was thought to be a gaseous nebula, called 'Little Cloud' on old star charts. In the early 20th century, novae were discovered in M31 consistently fainter than all previously found in our Galaxy. This, plus its spectrum looking more like stars than gas, added to the evidence that the nebula was indeed a distant island 'universe' similar to the Milky Way.

THE PLANETS

The evening sky in October is ideal for hunting planets. If you include the twilight period, six planets are available! Venus, spending the month below Mercury, is best observed low in the west around 30 minutes after sunset. Further up you'll find Jupiter near Antares in Scorpius. Higher again is Saturn to the right of the Teapot of Sagittarius. Neptune is well placed to observe in the evening too, transiting (due north) around 22:00 midmonth. Finally, Uranus is at opposition and up all night.

DEEP-SKY OBJECTS

This month, a brief visit to Sculptor. From the constellation's brightest star, Alpha (mag. +4.3), move 8° east to discover the challenging double star, Tau Sculptoris (RA 1h 36.1m, dec -29° 55'). This binary pair of yellow stars (mag. +6.0 and +7.3) currently are a snug 1 arcsecond apart – so be prepared to use high power under good seeing.

Lying in the same low power eyepiece field with Tau, 38'NW of the star is the impressive galaxy NGC 613 (RA 1h 34.3m, dec -29° 25'). This mag. +10 barred spiral has a small (0.5 arcminute) prominent core showing some mottling with a bright non-stellar nucleus. This is surrounded by a faint halo of approximately 4x2 arcminutes. Large apertures show hints of the curving spiral arms that extend from the ends of the bar. There is a mag. +9.5 star 2'NE.

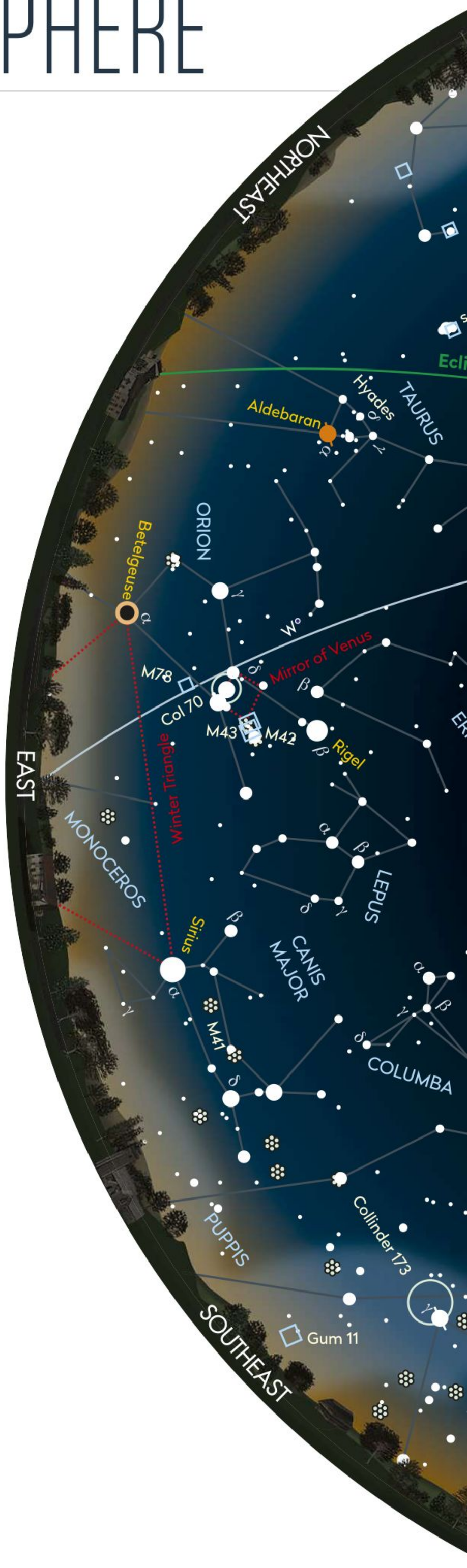
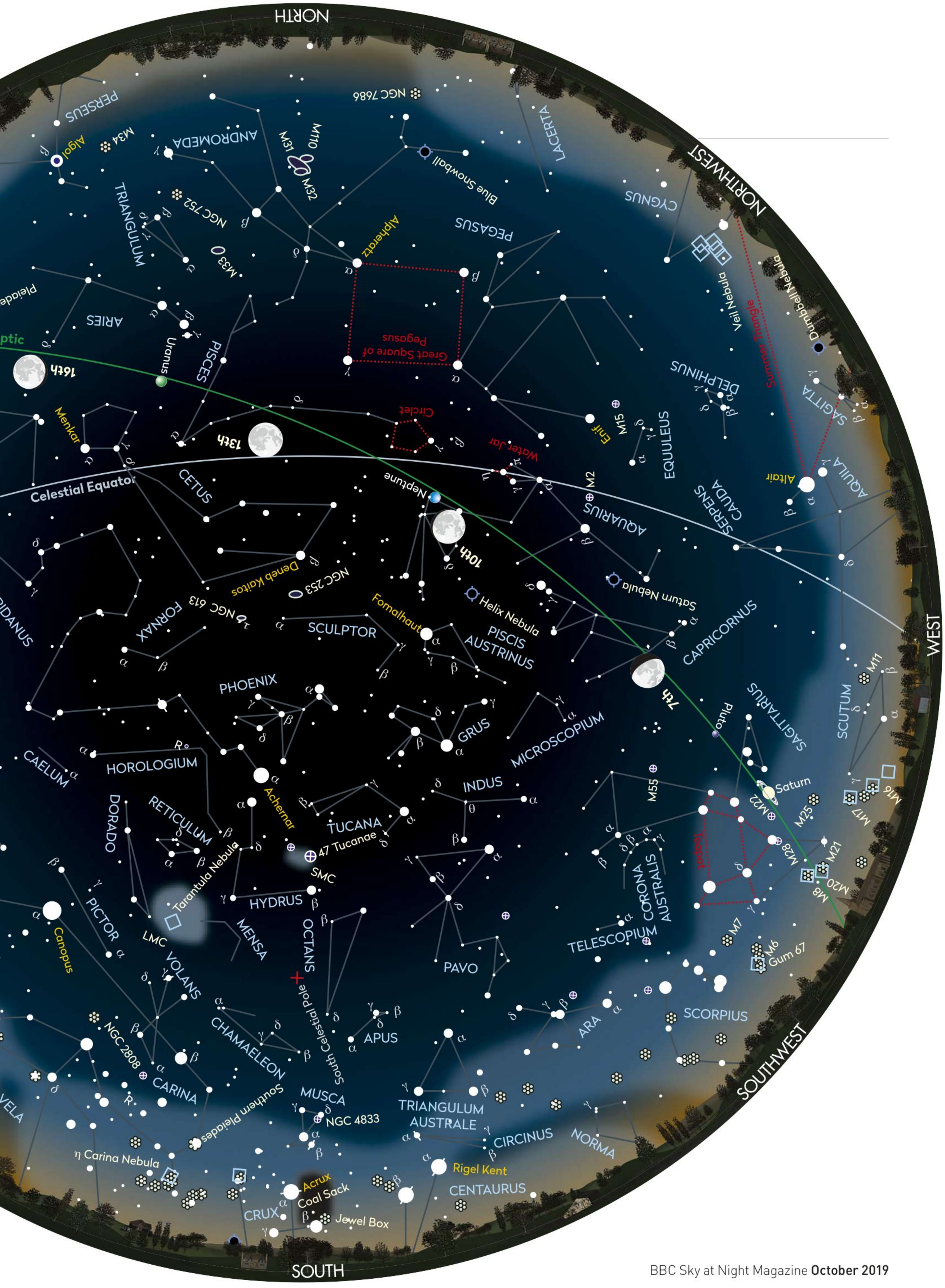


Chart key

- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- COMET TRACK
- ASTEROID TRACK
- METEOR RADIANT
- QUASAR
- PLANET
- STAR BRIGHTNESS:
  - MAG. 0 & BRIGHTER
  - MAG. +1
  - MAG. +2
  - MAG. +3
  - MAG. +4 & FAINTER

CHART: PETE LAWRENCE


NORTH
NORTHWEST
WEST
SOUTHWEST
SOUTH
PERSEUS
Algol
M34
ANDROMEDA
M110
M31
M32
NGC 7686
Blue Snowball
LACERTA
CYGNUS
Veil Nebula
Dumbbell Nebula
Summer Triangle
TRIANGULUM
NGC 752
M33
Alpheratz
PEGASUS
Great Square of Pegasus
Pleiades
ARIES
Uranus
PISCES
16th
Circlet
Menkar
13th
Celestial Equator
Water Jar
Enif
M15
EQUULEUS
DELPHINUS
SAGITTA
AQUILA
Altair
CETUS
Neptune
M2
AQUARIUS
SERPENS CAUDA
10th
Denab Kaitos
NGC 253
Helix Nebula
Saturn Nebula
FORNAX
NGC 613
Fomalhaut
SCULPTOR
PISCIS AUSTRINUS
CAPRICORNUS
DORADO
RETICULUM
Tarantula Nebula
Achernar
47 Tucanae
SMC
TUCANA
INDUS
HYDRUS
PHOENIX
GRUS
MICROSCOPIUM
HOROLOGIUM
CAELUM
7th
Pluto
Saturn
SAGITTARIUS
SCUTUM
M55
M22
M25
M28
M21
M20
M8
M17
M16
M11
Teapot
CORONA AUSTRALIS
TELESCOPIUM
M7
M6
Gum 67
PICTOR
Canopus
LMC
VOLANS
MENSA
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CHAMAELEON
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45mm Saddle
Product Code: 20302

Sky at Night MAGAZINE ★★★★★ REVIEWED IN Issue 121 June 2015

FREEDOM FIND™

SRP £1219

SYNSCAN™ COMPUTERISED HANDSET

HEQ5 PRO

Max Payload: 18kg
45mm Saddle
Product Code: 20886

Sky at Night MAGAZINE GROUP TEST WINNER 92%

SRP £969

EQ6 PRO

Max Payload: 25kg
Dual 45mm/75mm
Saddle
Product Code: 20854

Astronomy HOT Product

SRP £1239

EQ6-R PRO

Max Payload: 20kg (imaging)
Dual 45mm/75mm
Saddle
Product Code: 20855

Sky at Night MAGAZINE ★★★★½ REVIEWED IN Issue 145 June 2017

SRP £1429

AZ-EQ6GT PRO

Max Payload: 25kg Dual
45mm/75mm Saddle
Product Code: 20291

Sky at Night MAGAZINE ★★★★★ REVIEWED IN Issue 100 September 2013

SRP £1679

FREEDOM FIND™

EQ8 PRO

Max Payload: 50kg
75mm Saddle

Sky at Night MAGAZINE ★★★★★ REVIEWED IN Issue 108 May 2014

EQ8 PRO MOUNT HEAD

Product Code: 20292

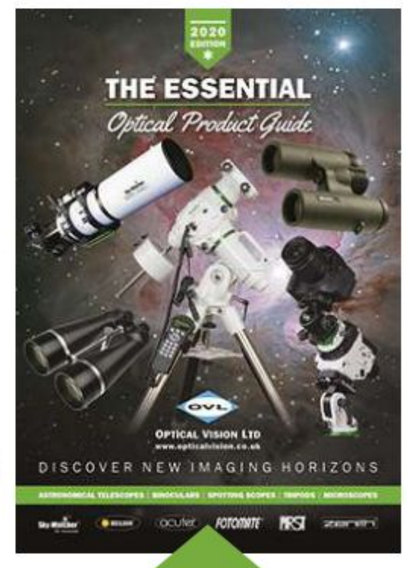
SRP £2899

EQ8 WITH PIER TRIPOD

Product Code: 20292/20293

SRP £3678

FREEDOM FIND™



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